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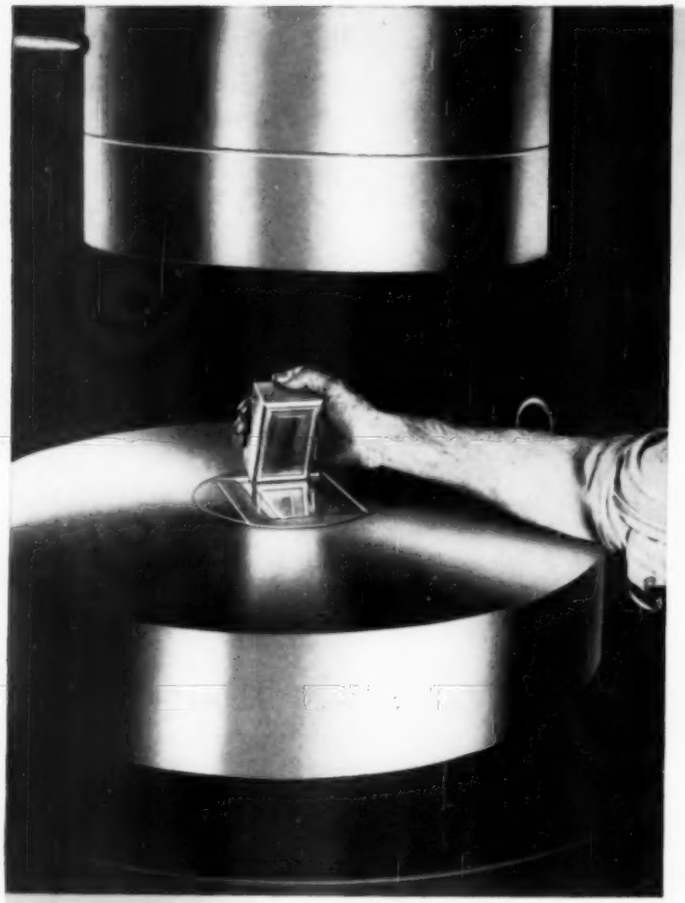
Plastics In America Exhibition

Constructed, except for steel frames, entirely out of plastic, this display shows over 400 plastic items used in American life. It will be part of U.S. Information Agency's overseas exhibition program. It is shown here set up at the United Nations Plaza.

PUBLISHED BY THE SOCIETY OF PLASTICS ENGINEERS, INC.

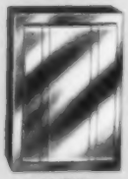


PENCIL CAVITIES HOBBED IN SOLID STEEL

MOLDED PIECES | HOBBED CAVITY | HOBBED CAVITY CUTAWAY VIEW

SKILLED HANDS *AND* GIANT PRESSES

combine to turn out consistently accurate hobbed cavities



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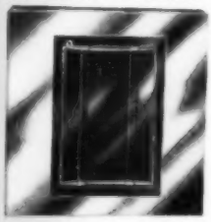
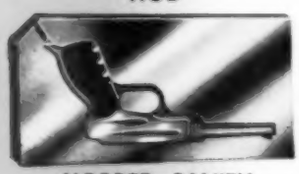


HOBBED CAVITY

HOB



HOBBED CAVITY

Of course, Newark Die Hobbing and Casting Co. operates a battery of high-capacity presses—up to 3,000 tons—for the making of hobbed cavities.

But even more important than the number and size of hobbing presses is the skill and experience of the craftsmen who operate them. Without this know-how, *a costly hob can be ruined in seconds!*

That is why the skill of Newark Die's craftsmen—men with up to 30 years of experience—is so important to users of hobbed cavities. Newark Die is prepared to make hobbings from your own hobs—or to design and construct the hobs for you.

Write for free booklet "How and When to Hob"

NEWARK DIE HOBBING AND CASTING CO.

22 SCOTT STREET, NEWARK 2, N. J. • PHONE: MArket 2-3305

A TECHNICAL REPORT from Du Pont

• *Properties and application data on ALATHON® polyethylene resin*

Coatings, film, tubings, closures and all types of molded products have extra advantages when made of "Alathon" polyethylene resin. "Alathon" is strong, lightweight, corrosion-resistant; is free from odor, taste and toxicity.

Important and expanding uses for "Alathon" include housewares, toys and flexible, long-service pipe for farms and industry. Outstanding dielectric properties and abrasion resistance of "Alathon" make it a superior insulating and jacketing material for electrical applications.

"Alathon" can be readily molded and extruded. Practically any size and shape container can be fabricated. Articles can be made in a wide variety of attractive colors.

Property data on this versatile engineering material are shown below. For further information on "Alathon" write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 425 Du Pont Building, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada Limited, P. O. Box 660, Montreal, Quebec.

Lightweight, flexible pipe of "Alathon" is easy to install, economical to maintain. It resists corrosion, can be installed above the frost line.

Housewares of "Alathon" can be fabricated in almost any size and shape. They're easy to keep clean, won't shatter, crack or dent.

Jacketing and insulation of "Alathon" for wire and cable have excellent dielectric properties, superior abrasion and heat resistance, and excellent weatherability.

MECHANICAL PROPERTIES		Units	Test method	
Tensile strength	−67 F.	lb. sq.in.	D412-51T	2,600
	73 F.	lb. sq.in.	D412-51T	1,750
	158 F.	lb. sq.in.	D412-51T	850
	−70 F.	lb. sq.in.	D638-52T	4,750
	73 F.	lb. sq.in.	D628-52T	1,900
	158 F.	lb. sq.in.	D638-52T	950
Yield point	−67 F.	lb. sq.in.	D412-51T	4,800
	73 F.	lb. sq.in.	D412-51T	1,700
	158 F.	lb. sq.in.	D412-51T	850
Elongation	−67 F.	%	D412-51T	60
	73 F.	%	D412-51T	600
	158 F.	%	D412-51T	600
Modulus of elasticity	73 F.	lb. sq.in.	D638-52T	35,000
Stiffness	−67 F.	lb. sq.in.	D747-50	230,000
	73 F.	lb. sq.in.	D747-50	27,000
	158 F.	lb. sq.in.	D747-50	8,000
Shear strength	73 F.	lb. sq.in.	D732-46	2,750
Impact strength, Izod	−40 F.	ft.lb. in.	D256-47T	0.8
	73 F.	ft.lb. in.	D256-47T	did not break
Hardness, Shore			D676-49T	C81,D48

THERMAL PROPERTIES			
Thermal conductivity	B.T.U./hr./sq.ft./°F./in.	Cenco-Fitch	1.75
Heat-distortion temperature, 66 lb. sq.in.	F.	D648-45T	121
Softening point, Vicat	°F.		201
Brittleness temperature	°F.	D746-51T	<−105

ELECTRICAL PROPERTIES	Units	Test method	
Dielectric constant			
60 cycles to 100 megacycles,		D150-47T	2.3
Power factor, 60 cycles			
to 100 megacycles		D150-47T	0.0005

MISCELLANEOUS PROPERTIES			
Flammability	in. min.	D635-44	0.94
Specific gravity		D792-50	0.92
Water absorption	%	D570-42	0.014
Melt index		D1238-52T	2.1
Index of refraction	n_D	D542-50	1.51
Mold shrinkage	in./in.		0.02-0.05
Compression ratio		D392-38	2.1–3.6

NOTE: Data shown are average values of molded "Alathon" 10. These values should not be used for specifications.

ZYTEL® nylon resin

ALATHON® polyethylene resin

TEFLON® tetrafluoroethylene resin

LUCITE® acrylic resin

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

U.S.I. POLYETHYLENE PROCESSING TIPS

Vol. 1, No. 3

Reduce Warpage in Injection Molding

Injection molded polyethylene articles frequently have a tendency to warp — especially if they are large and flat. While this is not serious in many cases, warpage of certain items such as container covers and drainboards presents a definite and sometimes difficult problem.

How can warpage be corrected? There is no single clear-cut solution to all cases. The problem can be solved by reducing the internal stresses that are set up in a molded part during cooling, and this may be done by adjusting mold conditions, changing to another resin, redesigning the mold, or a combination of these changes.

Molding Conditions Can Be Adjusted

Pressure should be held as low as possible. This allows some of the internal stresses to be relieved. Of course pressure must be kept high enough to avoid short shots.

Stock temperatures should be kept high to kill the elastic memory of the resin. This avoids those stresses that might otherwise be created by elastic memory.

Molds should be kept warm. Most of the internal stresses that cause warpage come from uneven cooling. By cooling slowly this effect is minimized.

Mold should be filled as rapidly as possible so that the entire part can be cooled at about the same rate.

OPERATING CONDITIONS FOR MINIMUM WARP

Molding Condition	Min. Warp
Pressure	low
Mold Temp.	balanced and warm
Stock Temp.	high
Gating Temp.	low
Injection Speed	high
M. I. of Resin	high

Mold Design For Minimum Warpage

Mold cooling should be concentrated around the gating where resin temperature is highest. With more cooling at the hottest point, temperature of the entire part can be reduced evenly with a minimum of internal stress.

Other mold design features are important too, especially the location of the sprue. The many other factors involved cannot be described here, but U.S.I. Technical Service personnel will be glad to discuss any individual situation.

Proper Resin Selection Can Decrease Warpage

Higher stock temperature and lower pressure can solve warpage problems, but they can create problems too, such as reduction of production rate. This can be compensated for by choosing resins with higher flow characteristics, such as PETROTHENE® 202 (M.I. = 22) or PETROTHENE® 203 (M.I. = 8).

These resins flow faster at lower pressures, so the lower pressure can be used without taking a production penalty. And the elastic memory of these resins can be killed at lower temperatures, so the machine can be operated with lower barrel temperature.

How much effect does a higher flow resin have on molding pressure and resin temperature? These rules of thumb apply in most cases.

1. Injection pressure can be reduced by approximately 25% when the resin melt index is doubled; assuming, of course, the same mold fill, cycle time and injection pressure.

Example:	M. I.	Pressure
Original Resin	2	1,000 psi
Other Resins	4	750 psi
	8	560 psi

2. Injection temperatures can be reduced by approximately 70°F when the resin melt index is doubled. This assumes the same fill, cycle time and injection pressure.

Example:	M. I.	Temperature
Original Resin	2	500°F.
Other Resins	4	430°F.
	8	360°F.

U.S.I. Offers Technical Assistance

The combination of machine conditions, mold design, and resin selection described above can result in a product with minimum warpage. But this combination may not be the best for optimum production rate, shrinkage, mold release, stress crack resistance, etc.

These other factors will be discussed in more detail, in future articles in this series, but if you have a particular problem now, why don't you call on U.S.I. now. Our Technical Service personnel will be glad to work with you toward finding a solution.

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SPE JOURNAL

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All nine winners in Koppers 1956 Design Competition for Plastics Housewares are assembled in the picture here, with a pretty model posing behind the portable rigid plastic bar which received Honorable Mention in Class I (polystyrene products for use with food). In the foreground are grouped the other winners —Best of Competition, First Prizes, and Honorable Mentions. They are the E-Z grip decanter, watering pot, self-watering flower pot, kitchen-size salt and pepper shaker set, four-piece canister set, pouring pail, and step-on can. Story on page 56.

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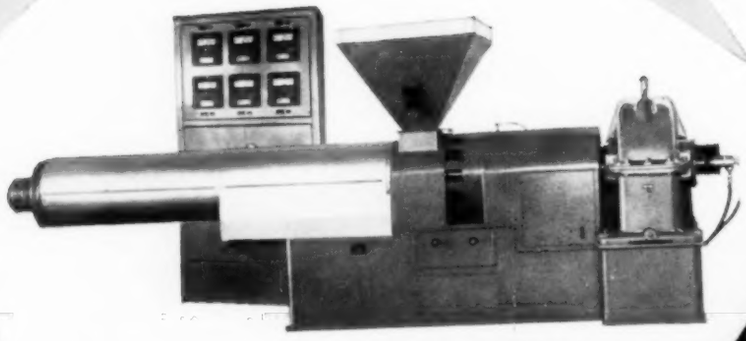

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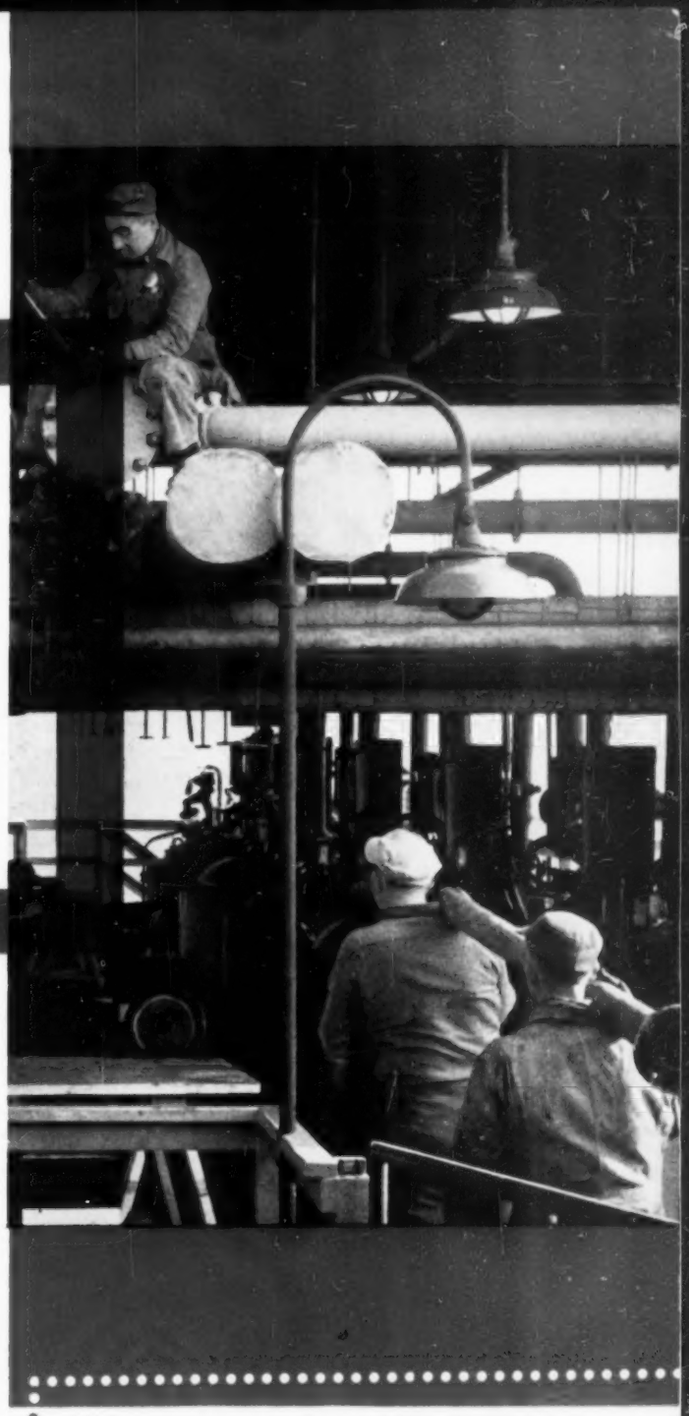

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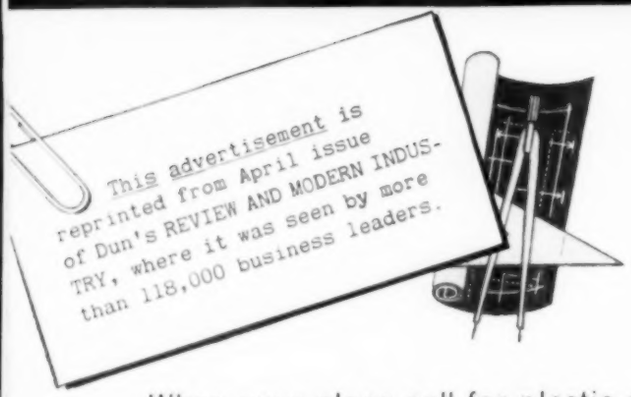
Craftsmen of the 20th Century

No. 14 of a series to introduce you to some of industry's outstanding plastics craftsmen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TRY, where it was seen by more
than 118,000 business leaders.

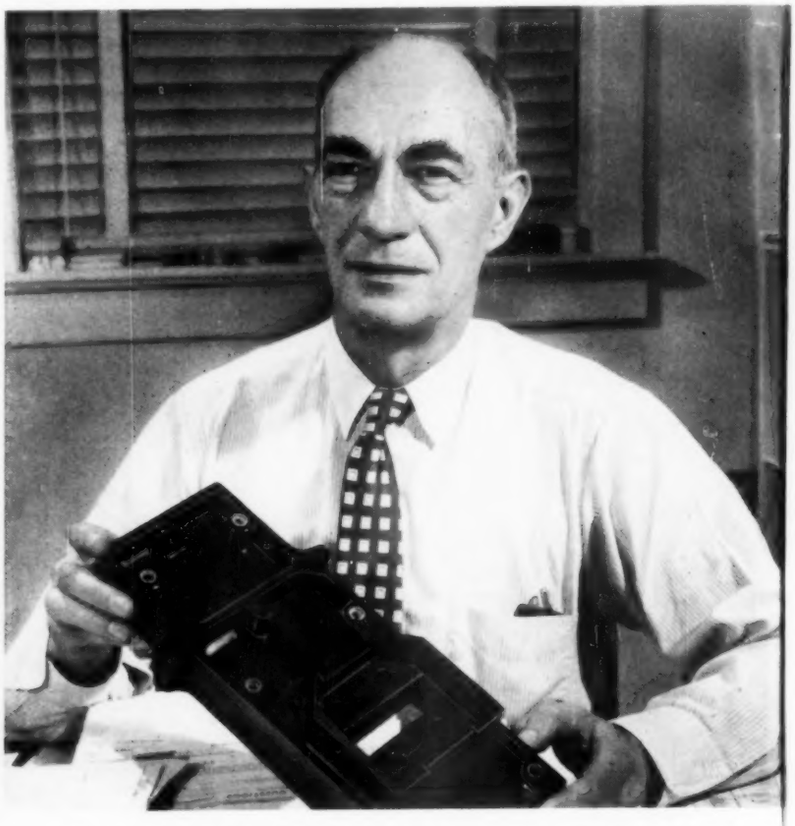
The artisans of other ages achieved their fame by thoroughly mastering a material. The world continues to celebrate their work in gold and silver, steel and glass and stone.

Today, a new family of materials is at hand which is challenging a new school of craftsmen. By devoting their skills to the custom molding of plastics, these men are contributing more and more low-cost articles to serve homes and industries everywhere.

Two of these 20th Century craftsmen are pictured on this page. Monsanto, a major supplier of high-quality plastic materials, salutes these men who are helping mold America's tomorrow.

When your plans call for plastic parts or products, consult an expert custom molder

Stefan T. Edlis, General Die Mold Company, Chicago. Originally a locksmith apprentice in his native Austria, Mr. Edlis has devoted the last 18 years of his life to the craft of toolmaking. Since 1945 he has been primarily concerned with the engineering of precision molds for plastics. As Production and Sales Manager for General Die, he supervises the output of 17 presses which run the gamut of injection and compression molding operations. Among his notable contributions to the custom molding industry is the design of new tools which improve the fabrication of intricate molds.



John W. Berthold, American Insulator Corp., New Freedom, Pa. There are few developments in the plastics industry that Mr. Berthold has not witnessed firsthand. His career as a tool designer for American Insulator dates back to 1922. Initially the company specialized in molding component parts for the electrical and automotive trade. Today, its widely diversified production includes radio cabinets, stove hardware, and parts for electrical appliances, air conditioners, television, aircraft, automobile and electronic assemblies.

IONSANTO CHEMICAL COMPANY,
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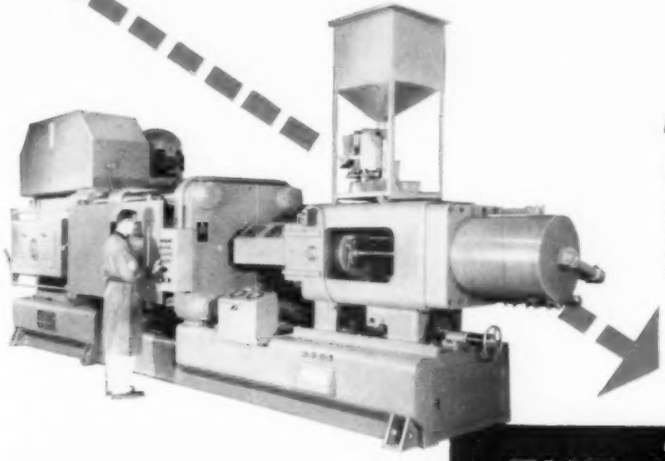
RESINOX

You Can Bank On H-P-M'S "48/64"

Tops For Big Polyethylene Parts

These big polyethylene waste baskets are typical of the big area, deep parts being molded on H-P-M's new Model 800-H-48 injection machine. This waste basket is molded in less than a minute. "Yes, the H-P-M "48" has everything," reports one molding superintendent . . . large injection plunger diameter to accommodate full capacity "shots" . . . plenty of stroke . . . large mold area. It's fast with straight line hydraulic mold clamp . . . high injection speeds . . . and plasticizing capacity for big parts at exceedingly high rates of speed.



Here's good news!

High speed H-P-M "48/64's" are now being built on stock orders that will assure excellent deliveries. Growing market demands have made the H-P-M 48 oz. a real favorite. See your H-P-M field engineer today—get your shop in shape for bigger, better, faster production.

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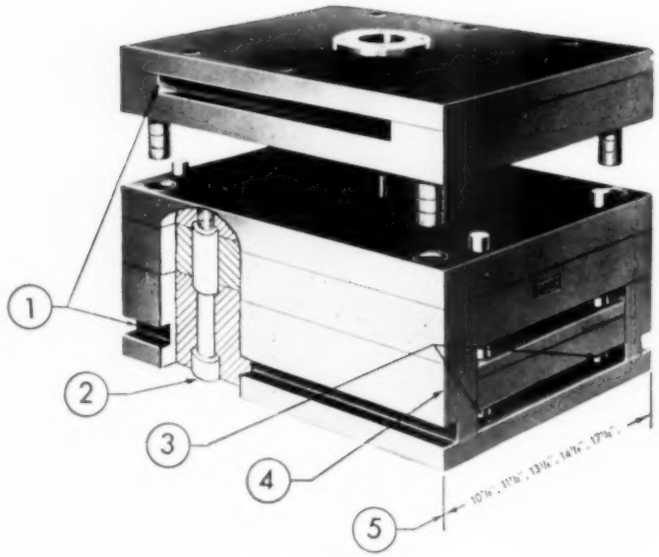

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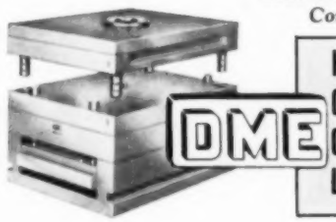

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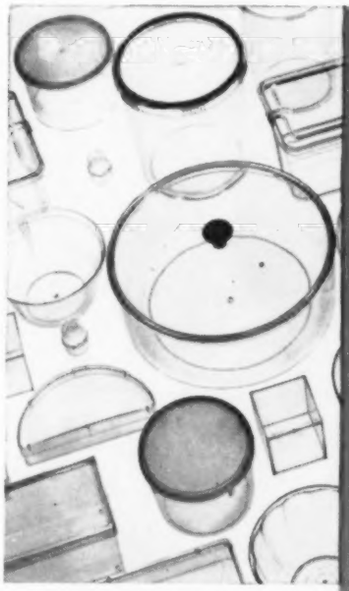
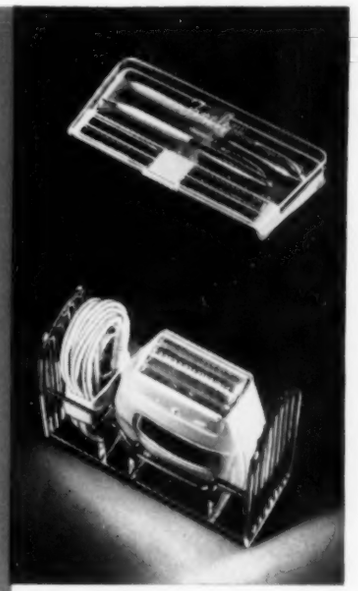
Below are typical applications of four Dylene formulations. If you would like more information about the family of Dylene polystyrenes, write to Koppers Company, Inc., Chemical Division, Dept. PW-46, Pittsburgh 19, Pennsylvania.

DYLENE 2

Outstanding flow properties of this plastic make it extremely useful in large-area, thin-section moldings. In high speed, fully automatic molding machines, Dylene 2 fills molds quickly at lower cylinder temperatures than are usually required for general purpose polystyrenes. It is used to make disposable packages, "egg crate" lighting panels, picnic spoons and tumblers.



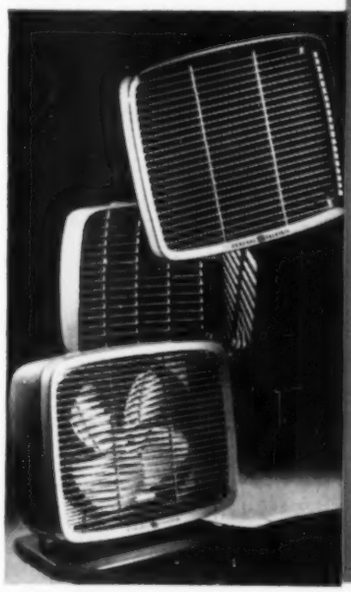


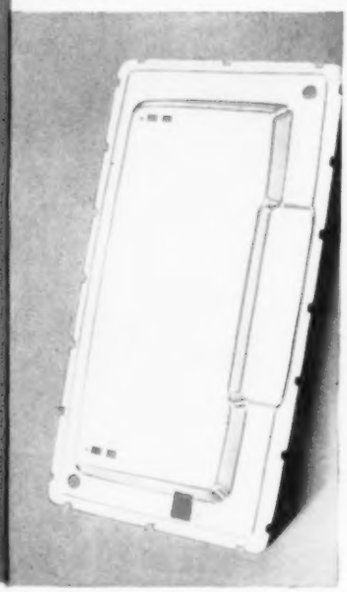
DYLENE 4

Easy flowing and fast setup characteristics make this plastic a real standout. Dylene 4 has greater strength and heat resistance than the usual easy flow polystyrenes. Result: faster cycling and ejection. This plastic is used to make combs, vials, thin-walled containers and display packaging items such as cases for pen and pencil sets and holders for electric shavers.

DYLENE 30

This medium impact polystyrene is not only easy to mold and fast to set up, but—it has a surface gloss and weld appearance that is almost indistinguishable from conventional polystyrenes. This unusual combination of properties makes this new plastic highly desirable for use in critical appliances such as air conditioner grilles, cosmetic caps and closures, housewares and toys.





DYLENE 200

Here is the easiest flowing polystyrene in the Dylene high impact line. Because of its easy molding properties, this plastic can be used in thinner sections than normal impact polystyrenes. It has excellent surface gloss and weld appearance. Dylene 200 is commonly used in refrigerator door liners, crisper trays, egg shelves, breaker strips and meat compartments, air conditioner grilles, housewares and toys.

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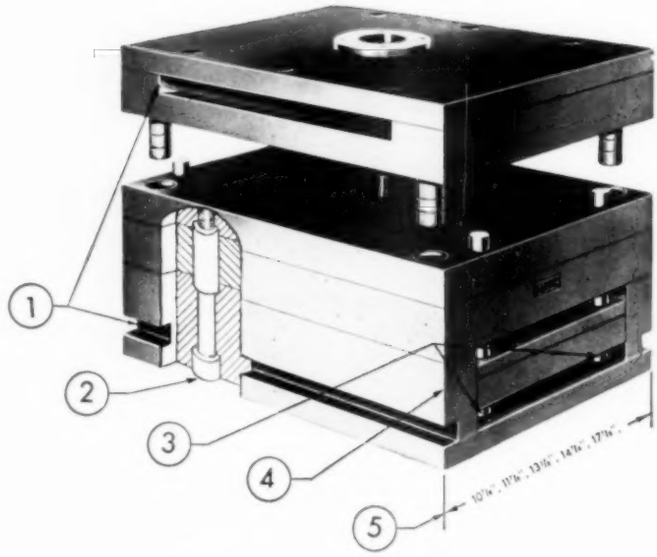

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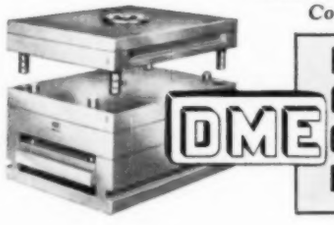

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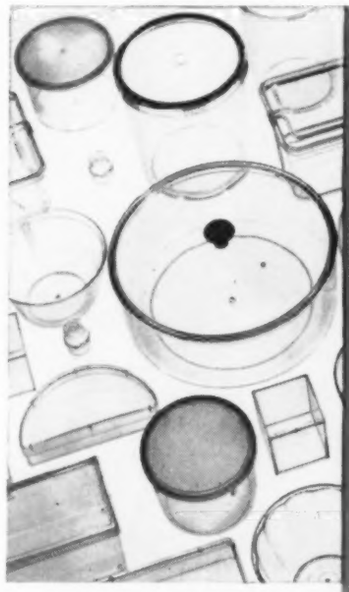
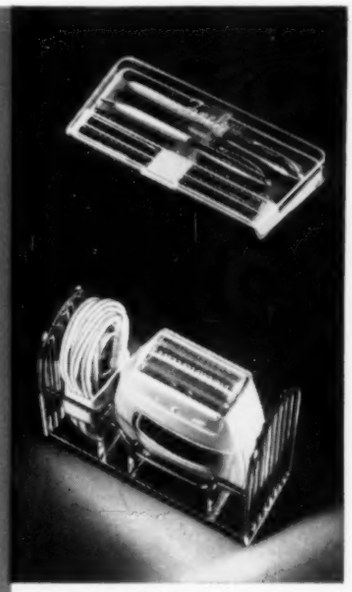
Below are typical applications of four Dylene formulations. If you would like more information about the family of Dylene polystyrenes, write to Koppers Company, Inc., Chemical Division, Dept. PW-46, Pittsburgh 19, Pennsylvania.

DYLENE 2

Outstanding flow properties of this plastic make it extremely useful in large-area, thin-section moldings. In high speed, fully automatic molding machines, Dylene 2 fills molds quickly at lower cylinder temperatures than are usually required for general purpose polystyrenes. It is used to make disposable packages, "egg crate" lighting panels, picnic spoons and tumblers.



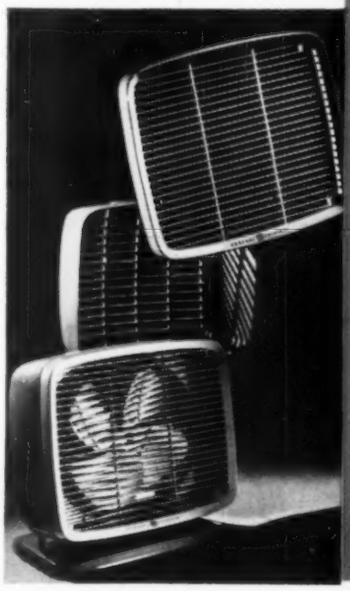


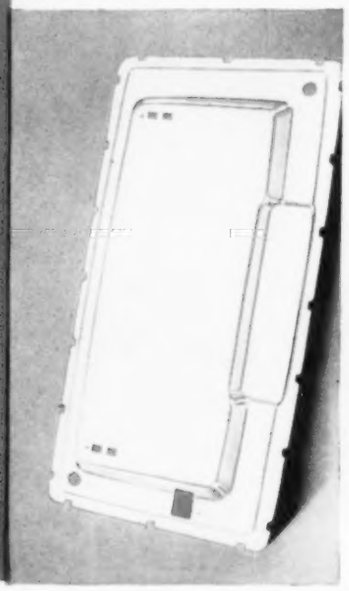
DYLENE 4

Easy flowing and fast setup characteristics make this plastic a real standout. Dylene 4 has greater strength and heat resistance than the usual easy flow polystyrenes. Result: faster cycling and ejection. This plastic is used to make combs, vials, thin-walled containers and display packaging items such as cases for pen and pencil sets and holders for electric shavers.

DYLENE 30

This medium impact polystyrene is not only easy to mold and fast to set up, but—it has a surface gloss and weld appearance that is almost indistinguishable from conventional polystyrenes. This unusual combination of properties makes this new plastic highly desirable for use in critical appliances such as air conditioner grilles, cosmetic caps and closures, housewares and toys.





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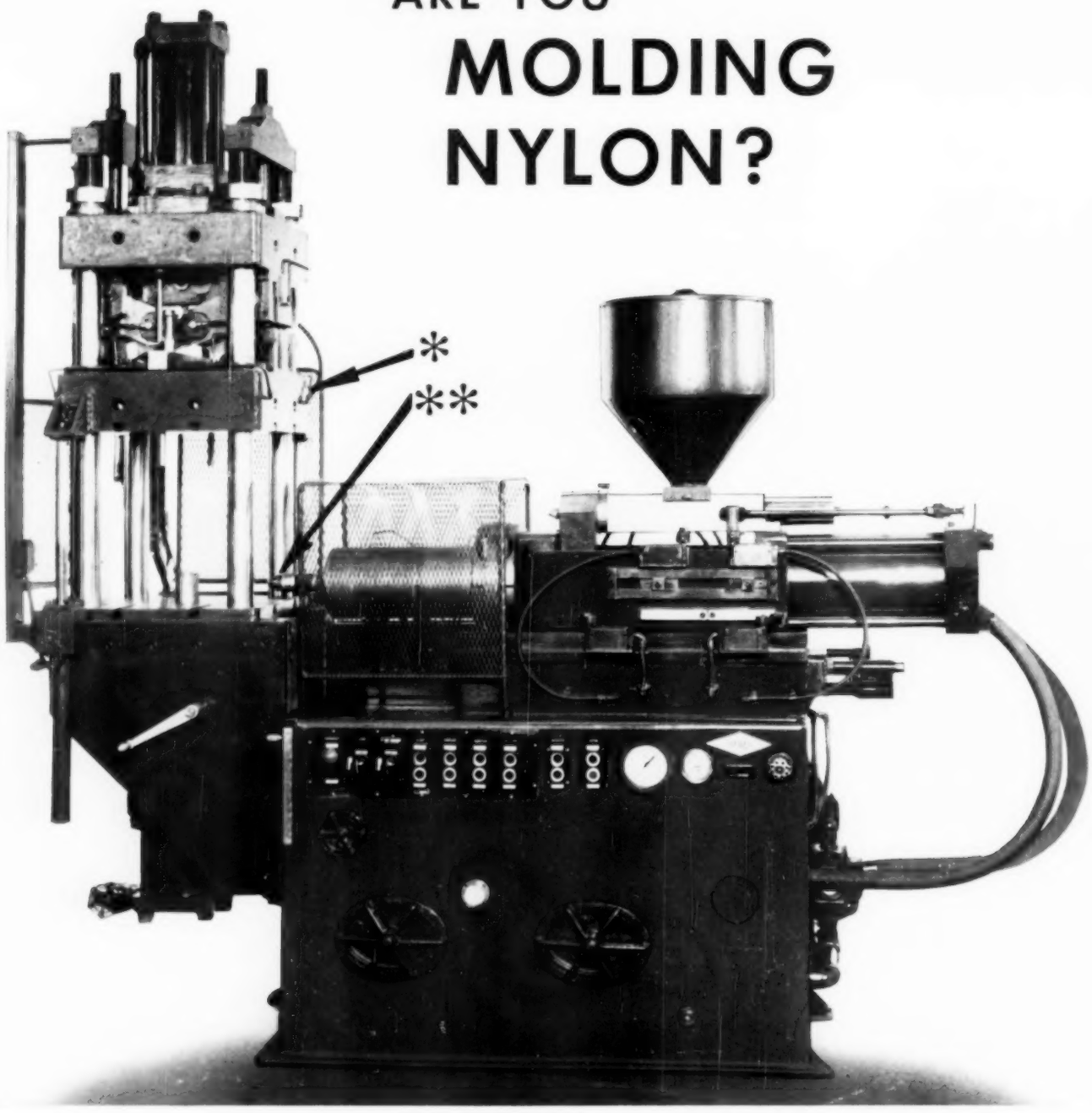

IMPCO VA4-175-19 — 4-6 OUNCES

SPECIFICATIONS

Injection Capacity	4-6 oz.
Injection Pressure (Plunger)	21,750 p.s.i.
Plasticizing Capacity (Polystyrene)	75 lbs. hr.
Clamp Pressure (Toggle)	175 tons
Clamp Stroke	8"
Die Thickness	Max-14" Min-8"
Machine Cycle (Dry Run)	7 Min.
Auxiliary Bottom Ram	19 Tons
Dimensions	Length-102", Height-112", Width-60"
Weight	Approx.-9000 Lbs.

**No drool problem with this easily controlled check valve type nozzle.

*Vertical type press-ideal for insert molding.

If you are a nylon molder, you must investigate this Impco machine!

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This makes them softer . . . easier on delicate surfaces. They soak up more water and distribute it evenly. Used dry, they pick up more dust particles because their characteristically electrostatic surface has been increased.

With these advantages . . . plus the other outstanding properties of BAKELITE C-11 Plastics, the monofilaments surpass natural bristles. These materials are resistant to most chemicals, staining, and temperature change . . . offer a range of colors . . . stay tough and resilient.

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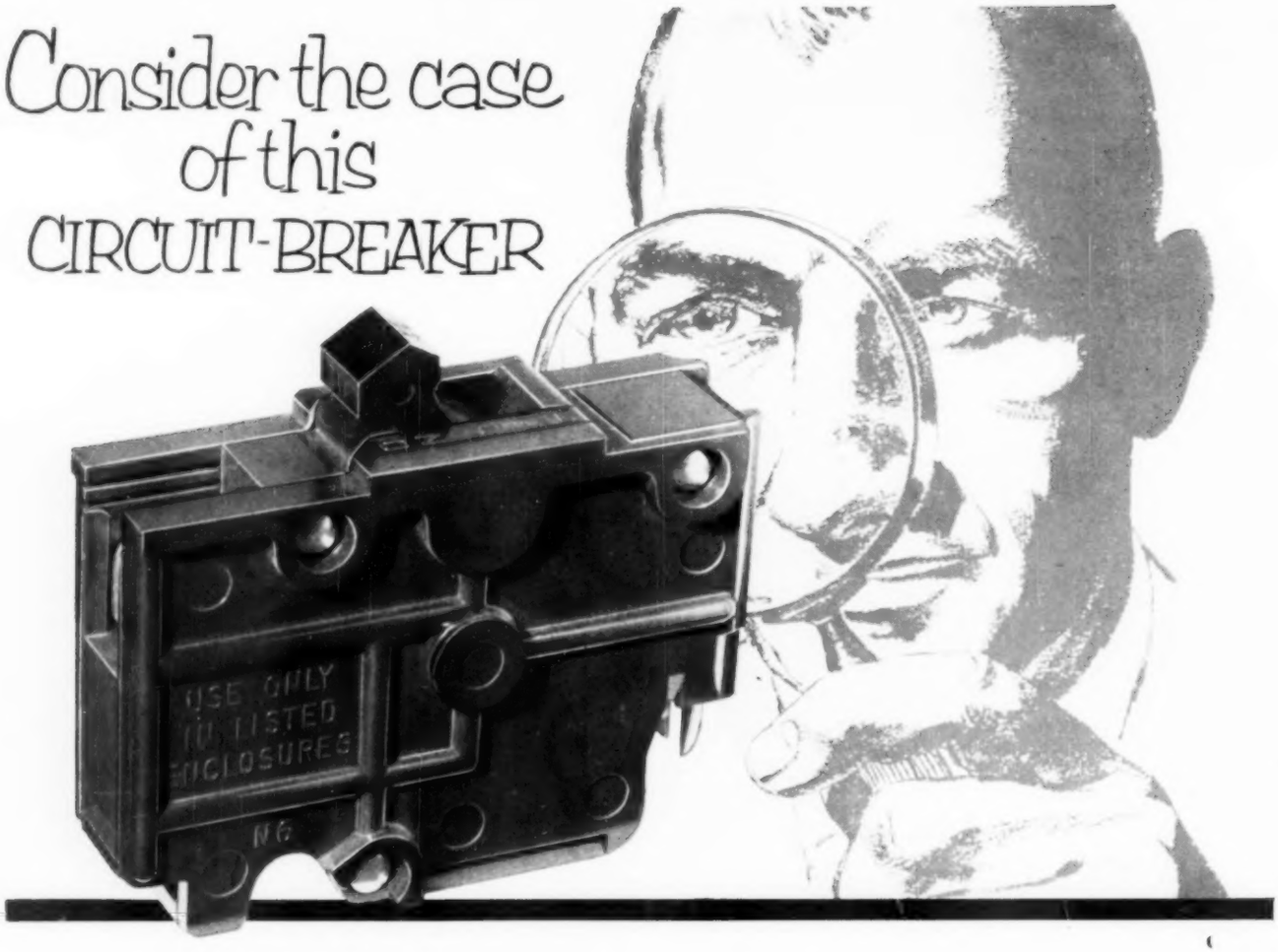
Consider the case of this CIRCUIT-BREAKER



...molded of arc-resistant, low-cost brown BEETLE® 1005

Consider the appliance: Federal Pacific Electric Company's *STABLOK* home circuit breakers. For the case, Federal Pacific needed a plastic that is dependable, attractive, easy to mold and reasonably priced. BEETLE Urea Molding Compound meets all these requirements.

Consider the advantages of brown BEETLE 1005 in this application:

- High arc resistance (greater than 100 seconds ASTM)
- Correspondingly high track and flame resistance
- High dielectric strength
- Speedy molding cycles
- Good moldability
- Good dimensional stability
- Low scrap loss (Federal estimates 2%)
- Low cost

Now consider what these advantages may mean to you in *your* application. Perhaps brown BEETLE 1005 would make a good case for *your* electrical parts – in appearance, service, molding and cost. Let us tell you more. Call or write any of the Cyanamid sales offices listed below.

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A New Measure of Plastic Moldability

Don B. Semeyn
The Dow Chemical Co.

Figure 1. Test piece for moldability

MOLDABILITY HAS BEEN, until now, one of those intangible unmeasurable things. Being unmeasurable it has been difficult for an engineer to understand.

The technique of injection molding has been largely reduced to a set of empirical rules which have been based on logical reasoning, scientific fact, and experience. Now we can add to these rules the ability to compare the moldability of thermoplastic materials with understandable numerical figures.

The development work in our lab at The Dow Chemical Co. in the study of moldability is similar to what every molding plant does in breaking in a new mold or determining the material best suited for a particular job. It is simply the determination of the best operating condition. This has been expanded to a set of systematic tests so that we can now compare materials and arrive at a moldability rating for each material.

Moldability is the ability to mold satisfactory parts with speed and ease. The word ease means both low machine settings and a wide range of machine settings; speed means high production rate and satisfactory parts mean low reject rate.

A test part was designed which would be difficult but possible to mold. To ascertain the cylinder temperature and injection pressure combination limits to mold a material, a molding area diagram is developed for this test mold. To find the speed with which a material may be molded and to determine the quality of molded parts, a minimum cycle for producing satisfactory parts is found in a systematic manner. The molding area diagram is reduced to a number which represents the size and location of the molding area. This is combined with the minimum cycle time to give a numerical moldability rating.

It is possible to arrive at moldability ratings which emphasize certain portions of the tests to suit a particular mold, job, or molder. For instance results could be weighted so that molding speed or perhaps minimum cylinder temperature requirements would be predominate in the final numerical rating. For our application we have attempted to arrive at a proper balance of all the test results which would compare to the average requirements.

From the material suppliers' point of view it was logical to think of moldability in terms of the various qualities of the material, since a change in any of the various qualities of a material could change the moldability of that material. These material factors include such things as melt viscosity, rate of change of viscosity with respect to pressure or temperature, volatile content, internal and external lubrication, granulation, specific heat, rate of heat absorption or dissipation, heat distortion temperature, heat stability, molecular weight, and molecular weight distribution. From a practical standpoint we wanted to be able to measure the moldability incorporating the proper balance of the effects of all these factors so that we could compare one material to another, preferably by a single numerical rating.

A mold was especially designed for the study of the problem. The molded part and cross section of the part is shown in Figure 1. A medium thickness of .070" was selected and the mold was sized at about half the rated capacity of the machine to be used to insure that the material and not the machine would be under test. Several undesirable features were incorporated into the mold to induce reasons for rejects. The part has a heavy rim and heavy knock-out lugs which will sink very easily. Vee-section and half round ribs or rings were included to interrupt the flow. The two cross-hatched areas serve the same purpose. The sprue-puller was designed with only a slight undercut which increases the possibility of cracking of the piece upon opening of the mold.

In our first test in the determination of moldability a molding area diagram is developed which determines the cylinder temperature and injection pressure limits with which a material may be molded in the test mold. As indi-

This paper was presented at the 12th SPE Conference.

Figure 2

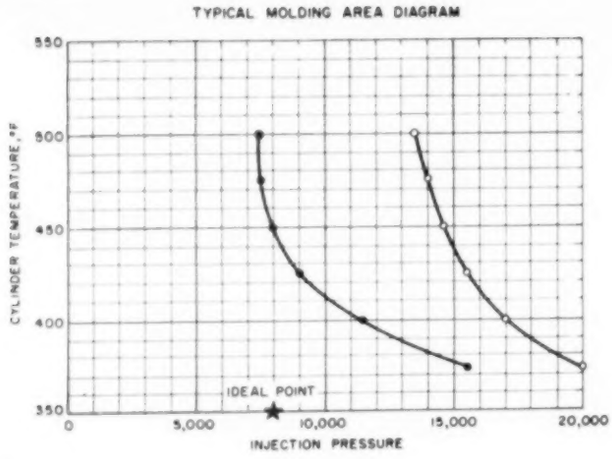
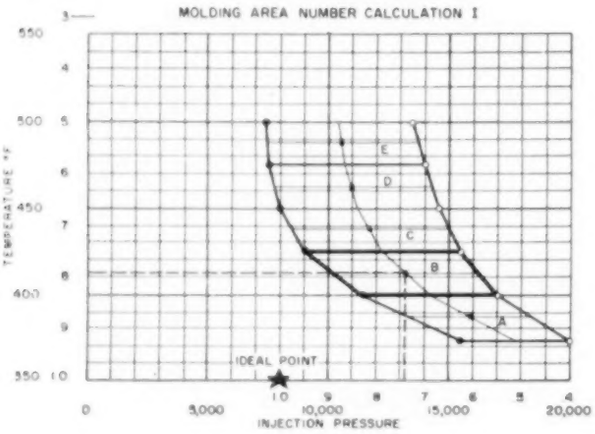


Figure 3



cated we have only two molding variables, cylinder temperature and injection pressure. The molding cycle, mold temperature, and so on, are held constant and, of course, the same machine, mold, and technique are used for all materials. The technique consists of gradually increasing the pressure at constant temperature until the mold cavity is just full and increasing further until it sticks or flashes. These two points are recorded on a graph. The cylinder temperature is then increased by a specific amount and a second set of short and flash or stick points are found. The process is repeated until the temperature limitations of the material are reached.

A typical diagram produced by this method is shown in Figure 2. The graph is a plot of cylinder temperature against injection pressure. At 375° F. it was found that the part was just full at 15,500 psi. and at 20,000 psi. the part stuck in the mold cavity. At 25° intervals of cylinder temperature these short and stick points are found and recorded. By connecting all the short shot points and all the stick points we have two curves which we call the short shot line and the stick line. The area between these two lines is known as the molding area in that full parts may be molded at any of the combinations of injection pressure and cylinder temperature that fall within the area. The molding area diagram shows the minimum temperature-pressure combinations under set conditions which the material can be molded in our test mold. It shows the range of combinations both pressure wise and temperature wise, it shows the maximum pressure-temperature combinations, and the molding temperature limitations of the particular material in this test mold.

In order to compare diagrams numerically it was necessary to select a point somewhere on the graph which would be considered ideal for molding. This "Ideal Point" was arbitrarily positioned at 8,000 psi. which is minimum injection pressure and 350° F. which is a low cylinder temperature for the polystyrene materials for which these tests have been used. This location was selected because it was considered to be the practical ultimate in low molding temperatures and pressures, not within the scope of present materials. The distance that a molding area diagram is from this ideal point and the size of the diagram are the two factors which combined give a numerical rating which has been named the "Molding Area Number."

Molding area number calculation: The molding area number is the summation of moments of particles of the diagram. Figure 3 shows the diagram divided into particles by connecting all the determined points on the curves with straight lines and forming trapezoids. The area of each trapezoid is found using the temperature and pressure scales which were used in the plotting of the diagram. These scales were used because of their convenience and the area so derived is considered only in square units.

For the moment calculation, the approximate center of each trapezoid is found by the intersection of the lines connecting midpoints of opposite sides. The moment of each particle is then the area of a trapezoid times the coordinates of its center. The coordinates for this moment determination are based on the Ideal Point and are of a reverse nature. The Ideal Point is denoted as 1 and the scales decrease progressing away from the point. In using decreasing scales, the closer the area is to the Ideal Point, which represents lower machine control settings, the larger the coordinates will be and therefore the moment of the particle. The Molding Area Number is then the sum of the moments of all the trapezoids which make up the molding area diagram.

The area of a trapezoid is equal to its height times the average length of its bases. For particle B then:

Area of B = $(425-400)\ \frac{1}{2}\ [(15.5-9) + (17-11.5)] = 150$

The moment of a particle is equal to its area times the coordinates of its center. For particle B then:

Moment of B = 150 x .792 x .738 = 88

The molding area number for the entire diagram is equal to the sum of the moments of the particles. The final numerical result is dimensionless and because of this the location of a decimal point has no real meaning.

Molding Area Number = $M_a + M_b + M_c + M_d + M_e$

We have reduced the diagram to a numerical figure which will be larger for materials which mold at lower combinations of cylinder temperature and injection pressure or at a wider range of combinations.

Test For Minimum Cycle

A second test incorporated in the study of moldability is the determination of the minimum cycle for producing satisfactory parts. In this test we systematically investigate a fairly wide range of logical mold and cylinder temperature combinations to determine the maximum speed at which a material may be molded. Because our test mold shot size is only about half the rated machine shot size, we are sure it will not exceed the plasticizing capacity of the heating cylinder. Constant cycling is maintained throughout the test to insure that each shot has received an equal amount of heat. A good many shots are made between any changes in overall cycle time to prevent any false effects.

From the molding area diagram the minimum mold-

ing temperature is used as a basis for the minimum cycle determination. The cycle used in plotting the molding area diagram is kept as a starting point and booster time is added to facilitate filling. The material is weigh-fed into the cylinder. Minimum plunger forward time is first determined while maintaining a constant cycle by adding any time removed from the plunger forward timer to the mold closed timer and keeping mold open timer constant. After this is determined, time is removed from the mold closed timer and thereby reducing the overall cycle. The end point in both of these determinations is, of course, when satisfactory parts are no longer produced. This is repeated for several selected mold temperatures. After these mold temperatures are explored the cylinder temperature is increased by 100 F. and another set of mold temperatures are investigated. The selection of cylinder temperature and mold temperature combinations is based on the usual practice of using a low cylinder temperature with high mold temperatures or a high cylinder temperature with low mold temperatures.

Thus we have a fairly thorough test which gives the minimum molding cycle which shows the speed with which the mold may be filled, how fast the material sets up in the mold and because emphasis is always on satisfactory parts we evaluate the material for shrinkage, silver streaking, black streaking, cracks, gas traps, and the like.

Figure 4 is a composite of test results and how the many material factors affect these test results. The inner circle represents the two tests and radially from the tests, the test results in the second circle and the factors that affect these results in the third. Most of these test results are affected or determined by combinations of material factors and almost every factor affects more than one result. The test results of the two tests tell us what machine control settings are necessary, the speed with which it will be possible to mold with a material and reasons for rejects. As stated earlier this is the ease with which a material may be molded into satisfactory parts, so there we have moldability.

By combining the numerical test results, the molding area number and the minimum cycle time, we have moldability in one number. Since the lower or larger molding area diagrams have larger numbers and the faster molding materials have smaller cycle times, this combination is accomplished simply by division of the molding area number by the minimum cycle time. We have named this number rating for the material the "Moldability Number."

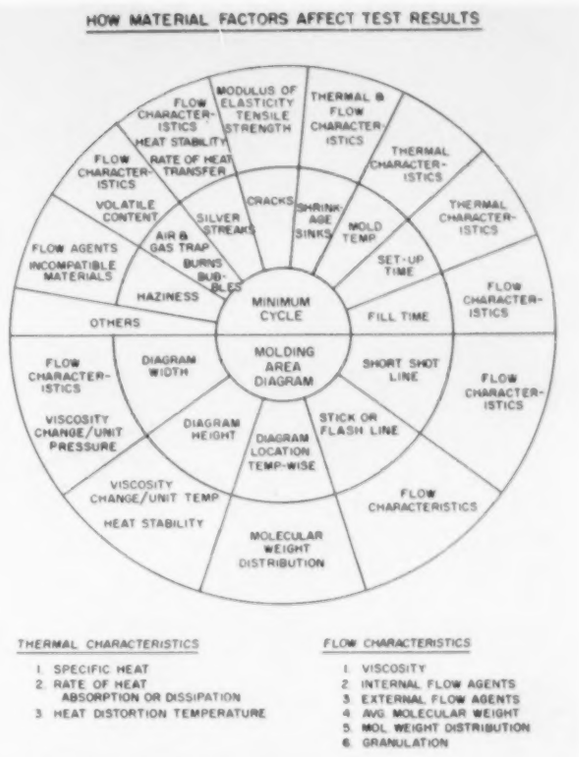
$$\frac{\text{Molding Area Number}}{\text{Minimum Cycle Time}} = \text{Moldability Number}$$

The practical application of the results of this test are shown in the table below. The moldability of several high impact type polystyrene materials have been compared by this test. The table shows the molding area numbers divided by minimum cycle times to arrive at moldability ratings for each material. The difference between moldability numbers is of importance rather than the actual numerical values. The location of a decimal point has no real meaning since the number is dimensionless.

Moldability Ratings of High Impact Polystyrenes

A	647/22	=	29.3
B	710/25	=	28.4
C	665/24	=	27.9
D	592/23	=	25.7
E	599/24	=	24.9

We have in this number a practical useful tool to use in the study and comparison of materials. The moldability of experimental, special, or new materials may be accurately determined and we will know exactly where



they may fit into the competitive picture. Or we can determine from the tests which material factors or qualities should be modified to cause a desired change in moldability.

Discussion

Q: Have you investigated differences in short shot lines by low injection pressure versus cutting back plunger forward timer? If you have done this what differences have you found?

A: I am sorry to say that we have not done sufficient investigation on this subject to make intelligent comments. This method of controlling fill is more adaptable to thin sections and pin point gates and, of course, our test mold is .070" and has no gate.

Q: What influence does geometry (e.g. thickness of item) have on the moldability number?

A: Materials intended for different end applications have different flow and setting characteristics which would show up very readily in different thickness parts. Easy-flow polystyrene materials which were developed for thin section molding are slow setting. High temperature resistant polystyrene co-polymers are stiff flowing and fast setting. The relative two types of materials would reverse themselves in changing from thin to thick section moldings.

Q: How does molecular weight and molecular weight distribution affect moldability?

A: The flowability of a polymer is dependent on its molecular weight (barring cross-linking). That is, with all other variables equal, such as lubrication, the higher the molecular weight the stiffer the flow.

All polymers are a combination of different length chains. The average length is the average molecular weight reported. The molecular weight spread or distribution then will include some material of both higher and lower than the average. The actual range of this spread will affect flowability since the higher molecular weight material will stiffen the melt and the lower will act as a lubricant.

Characteristics of Biaxially Stretch-Oriented Acrylics

Attention has been focused on the improvement in service quality that may be expected when highly stretched acrylic sheet is used in aircraft canopies. The characteristics of biaxially stretch oriented acrylics depend upon the degree and to lesser extent, upon the manner of stretching. This paper concerns the properties of biaxially stretch oriented acrylics which help to preserve the integrity of aircraft canopies made from this material.

D. A. Hurst
Rohm and Haas Co.

POLYMERIC MATERIALS have been shown to consist of networks of long-chain molecules which are held together by chemical bonds, strong attraction between chains, and chain entanglements. The physical changes which occur during the stretching of a polymeric material at temperatures above T(sub g) involve changes in these specific characteristics.

With increase in percent stretch there is progressive orientation of the individual chain molecules in the direction of stretch. These physical charges can be observed optically by means of birefringence. Studies of the birefringence of stretched acrylics have been made at the Naval Research Laboratory and will not be discussed in the present paper. (1)

Early work on stretched acrylic plastics at the National Bureau of Standards and at the Rohm & Haas Company Laboratories showed greatly improved crazing resistance and impact strength as compared to unstretched material. Our later investigations of the effects of stretching on the properties of acrylic material conforming to Specification MIL-P-5425A were conducted under the sponsorship of the Materials Laboratory, Wright Air Development Center. In cooperation with the Naval Research Laboratory, Mechanics Division, stretched acrylic plastics were also evaluated for crack propagation properties as measured by the work required to cause a crack to propagate. This is called the dW/dA value of the material.

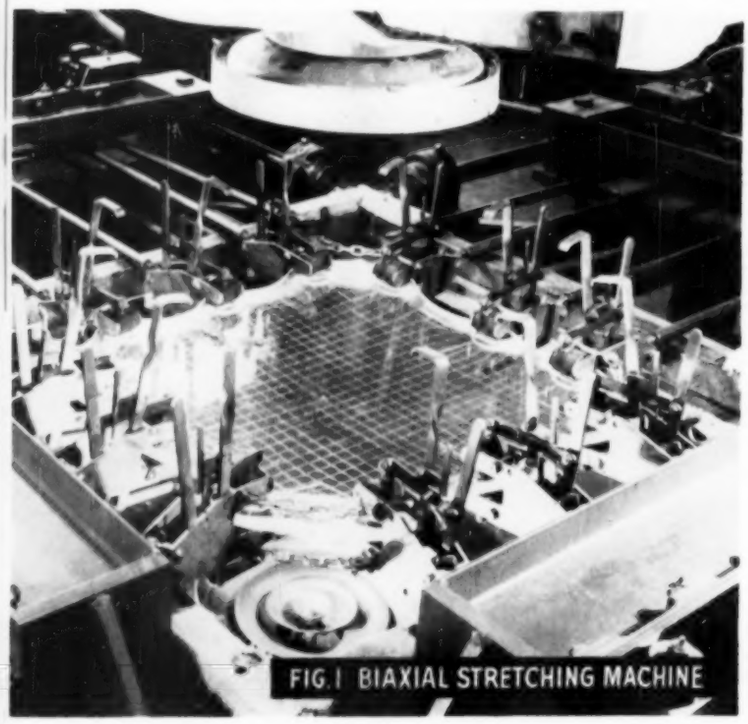


FIG. 1 BIAXIAL STRETCHING MACHINE

Biaxial stretching was done under controlled conditions with the equipment that was designed and built for use in the WADC contract. Figure 1 shows a view of this machine with the hood raised after completion of stretching. The uniform stretch in both directions is apparent from observation of the uniform grid pattern which was marked on the sheet before stretching. The rate of stretching was maintained at 2.5 inches per minute by means of a variable speed drive. Prior to stretching, the thick sheet material was preheated in a forced air circulating oven for 100 minutes per inch of thickness. During stretching the temperature within the enclosed stretching area was accurately controlled.

Definition of Stretch

The Organic Plastics Section, National Bureau of Standards, investigated the effects of 50% biaxial stretch-forming on the tensile and crazing properties of commercial cast polymethyl methacrylate sheets. (2, 3) In another paper presented at the Toronto meeting of SPE in 1954, I. Wolock and D. A. George discussed the work done at the National Bureau of Standards on the effect of stretching on crazing and strength properties of transparent plastics. (4) The stretching equipment which they used produced relatively uniform stretch in all directions in the plane of the sheet. The amount of stretch was calculated as follows:

$$\text{Percent stretch} = 100[(t_i/t_a)^{1/2} - 1]$$

where

t_i = initial thickness
t_a = final thickness

We shall call this multiaxial stretching to distinguish it from the biaxial stretching in which the sheet is stretched in two directions that are perpendicular to each other in the plane of the sheet.

This paper was presented at the 12th SPE Conference.

The calculation of percent biaxial stretch was based on the linear dimensions of the sheet rather than on the thickness.

S_l = Percent biaxial stretch = 100 (L_2/L_1 − 1)

S_k = Percent biaxial stretch = 100 (W_2/W_1 − 1)

where

L_1 = length of unstretched sheet

L_2 = length of stretched sheet

W_1 = width of unstretched sheet

W_2 = width of stretched sheet

For equal biaxial stretch, $S_l = S_k$. $L_2/L_1 = W_2/W_1 = (t_1/t_2)^{1/2}$ and percent stretch = 100 $[t_1/t_2]^{1/2}$ − 1.

Testing Procedures

Stress-only and stress-solvent crazing resistance tests on biaxially stretch oriented acrylic sheet were made with 1 x 7 inch specimens mounted as Class I levers in test jigs as shown in Figure 2. Cantilever beams were cut with their long axis parallel to direction S_l and were loaded at the free end to produce the desired test stress for ten minutes before applying solvent. Ten minutes after the solvent was applied, the outer fiber stress to cause crazing was calculated from the distance of the extent of crazing boundary to the point at which the load was applied. The stress-solvent crazing tests were run indoors with the solvent applied to the area of the specimen above the fulcrum point.

Izod impact strength was measured in accordance with Federal Specification L-P-406b, Method 1071, except that the test specimens were unnotched and the specimens were struck flatwise.

The reaction of the stretched acrylic to stress concentrations was investigated by means of notch sensitivity tests, also by crack propagation tests run at the Naval Research Laboratory. Notch sensitivity was determined in a modified flexural test with specimens having an 0.005 inch deep scratch extending to within 0.05 inches of either edge of the tension side of the specimen. The scratch was at the mid-point and was perpendicular to the long axis of the test specimen. Tests were made in accordance with ASTM method D790-49T, using a 4 inch span and a crosshead motion rate of 0.10 inches per minute.

B. M. Axilrod, et al, at the National Bureau of Standards demonstrated the laminar appearance in the fracture surfaces of tensile specimens of stretched acrylics which favors fracture propagation on planes nearly parallel to the plane of the sheet. (5) Other studies of fracturing phenomena at the Mechanics Division, Naval Research Laboratory, show considerable difference between the laminar type fracture appearance of stretched and the fracture appearance of unstretched acrylic sheet. (6) The many common characteristics of fracture markings on metals, plastics, and ceramics have been described in several papers. (7, 8) M. Bowman, Jr., and H. L. Smith, of Naval Research Laboratory, determined the work to create fracture surfaces in polymethyl methacrylate. (9)

The general method developed at Naval Research Laboratory for the study of fracturing phenomena in metals and plastics uses a centrally notched plate in tension. (10, 11, 12, 13) The dW/dA value (expressed as inch pounds per square inch) has been defined as the work per unit of projected area of crack extension at the instant when the rate of crack propagation changes from slow to fast over several magnitudes of speed. The crack length measured at the point of instability can easily be determined by reading the fracture mark-

FIG. 2 STRESS-CRAZING JIG

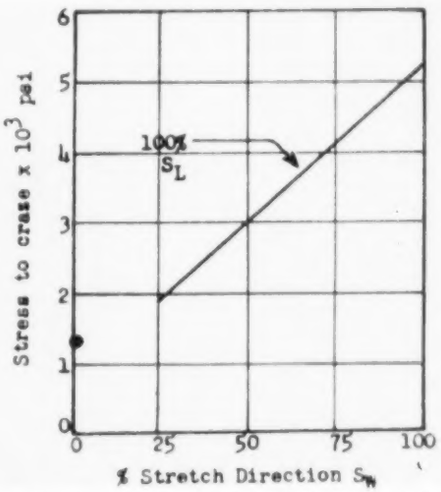


Figure 3. Crazing with isopropyl alcohol. Beams tested with l axis parallel to S (sub w).

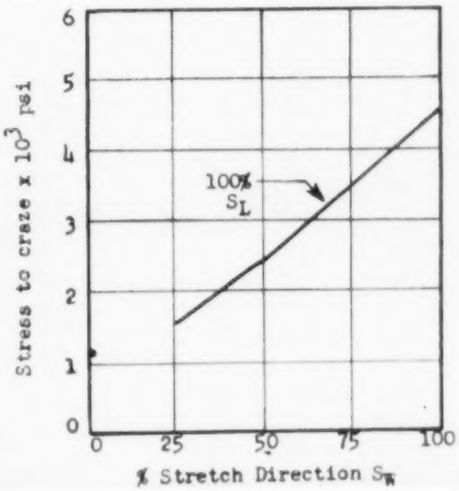


Figure 4. Crazing with lacquer thinner. Beams tested with l axis parallel to S (sub w).

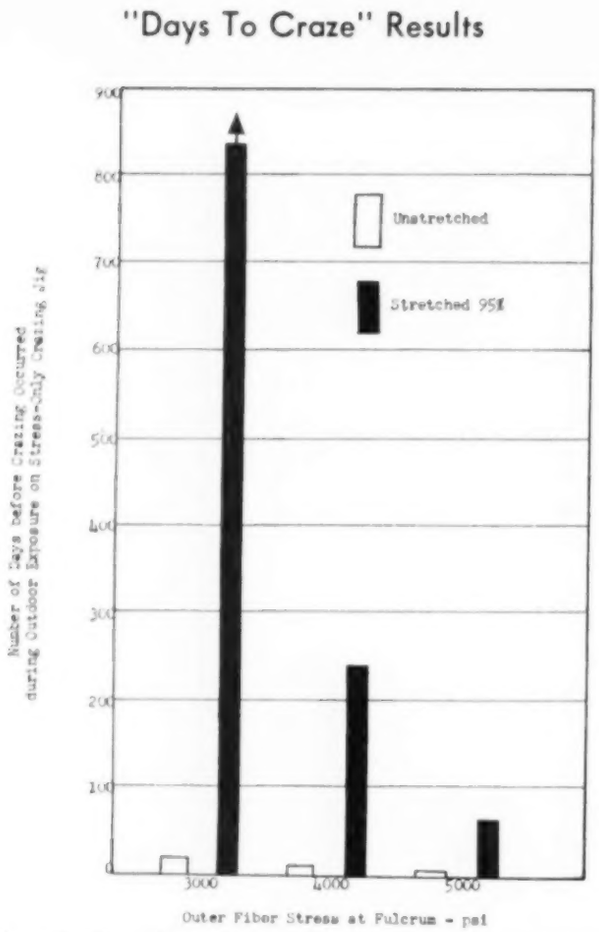


Figure 5. Effect of stretching on stress-only crazing of multiaxially stretched MIL-P-5425 material.

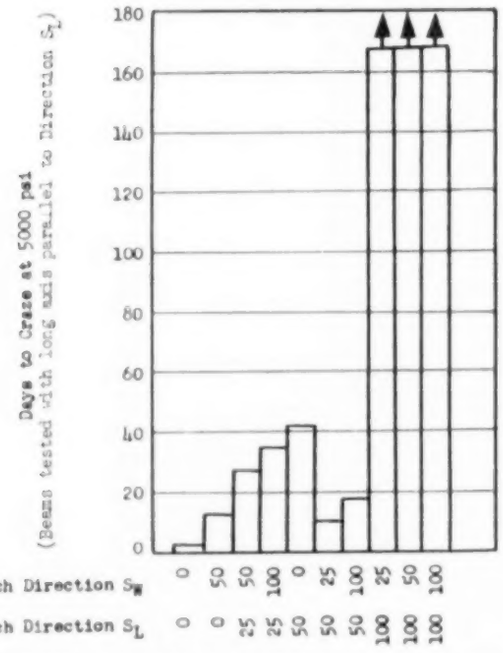

Days to Craze at 5000 psi (Beams tested with long axis parallel to Direction S_L)
180
160
140
120
100
80
60
40
20
0
% Stretch Direction S_W 0 50 50 100 0 25 100 25 50 100
% Stretch Direction S_L 0 0 25 25 50 50 50 100 100 100

Figure 7. Stress-only crazing after six months of aging at 50°C. (122°F).

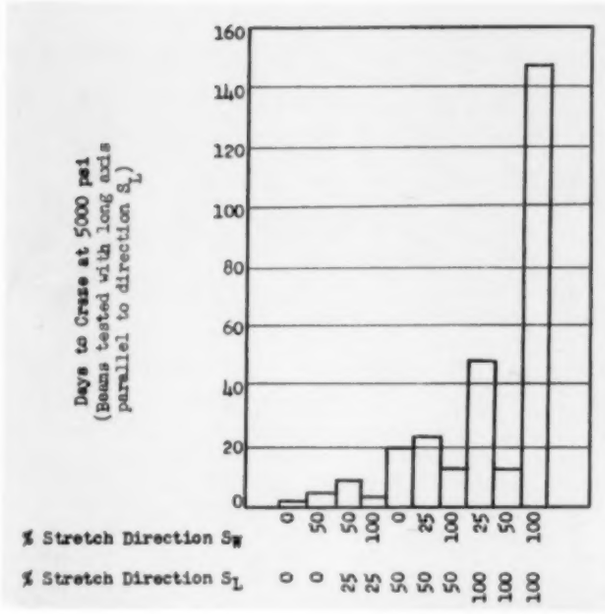

Days to Craze at 5000 psi (Beams tested with long axis parallel to direction S_L)
160
140
120
100
80
60
40
20
0
% Stretch Direction S_W 0 50 50 100 0 25 100 25 50 100
% Stretch Direction S_L 0 0 25 25 50 50 50 100 100 100

Figure 6. Stress-only crazing after six months of outdoor aging.

ings as described above. The dW/dA values are calculated using the formula:

$$dW/dA = \pi P^2 Z/BYt^2$$

where

P = load in pounds at point of rapid fracture
B = width of specimen in inches
Y = Young's Modulus
t = plate thickness
X = crack length at instability
Z = a function of X/B (obtained from a table)

The results of dW/dA tests at Naval Research Laboratory on 6 x 8 inch specimens tested at room temperature have been treated by statistical methods.

Test Results

Stress-Solvent Crazing

The stress-solvent crazing resistance increases with increase in percent stretch to 100%, which was the maximum percent stretch for these investigations. Cantilever beams mounted as Class I levers with their long axis parallel to direction S_L are tested with isopropyl alcohol or lacquer thinner applied above the fulcrum point. The outer fiber stress required to cause crazing at different percent stretch is shown in Figures 3 and 4. The stretch in direction S_L was constant at 100% and stretch in direction S_k varied from 25% to 100%. Where S_k is less than 100% stretch, there is unequal biaxial stretch. This is stretch along the two axes 90° apart, with less stretch in S_k than in S_L direction.

Stress-Only Crazing

The improvement in stress-only crazing resistance of **multiaxially** stretched compared to unstretched acrylic is shown in Figure 5. This material with 95% stretch did not craze during 825 days outdoor weathering at 3000 psi outer fiber stress. Figure 6 shows the stress-only crazing results on the biaxially stretched acrylic after six months outdoor weathering and then tested at 5000 psi outer fiber stress with the long axis of the beam parallel to direction S_L. The improvement in crazing re-

sistance of the 100% stretched material as compared to lower percent stretch is very evident. When the material is aged for six months indoors at 50°C (122°F) and 15% relative humidity before testing, the stress-only crazing resistance is greater than for outdoor weathering where moisture absorption can affect the results. Figure 7 shows the crazing of indoor, elevated-temperature aged material.

Izod (Unnotched) Impact Strength

The Izod (unnotched) impact strength of biaxially stretch oriented acrylic sheet increases with increase in percent stretch as shown in Figure 8. The test specimens were mounted flatwise in the testing vise and struck normal to the plane of the sheet. At the highest percent stretch the fractures became more fibrous in texture and there was a tendency for laminar type fracture in the free end of the specimen.

Shear Strength

When tested normal to the plane of the sheet, stretched material has about the same shear strength as unstretched sheet. However, shear strength measured parallel to the plane of the sheet may show reduction amounting to as much as 50% of the unstretched material tested in accordance with Method 1031 of Federal Specification MMM-A-175. This may be important in the design of edge attachments.

Notch Sensitivity

The notch sensitivity of stretched acrylic sheet is significantly reduced with relatively low degrees of stretch. Figure 9 shows the increase in flexural strength of stretched material which is the measure of decrease in notch sensitivity. There is relatively small change in flexural strength in going to higher degree of stretch as compared to that for lower stretch.

Crack Propagation Resistance

The magnitude of the dW/dA values is used as the basis on which crack propagation resistance of stretched material is evaluated. Data obtained at NRL on MIL-P-5425A acrylic sheet stretched 100%, 73%, and 40% have been summarized in Tables I, II, and III respectively.

Since widely different conditions of stretching or post-stretch heat may affect the results of the dW/dA tests, it is necessary to describe the stretching method. The material was biaxially stretched in the machine as shown in Figure 1. The elapsed time during stretching of the sheet was from 3 to 6 minutes with the longest time corresponding to the highest degree of stretch. The nominal thickness of unstretched MIL-P-5425A material required to produce approximately 0.250 inch thick stretched material is as follows:

Nominal Thickness Unstretched	Percent Stretch
0.375 inches	25
0.500 inches	50
0.750 inches	75
1.000 inches	100

The maximum rate at which the material could be stretched was $2\frac{1}{2}$ inches per minute. This is governed by the rate of clamp separation which, in turn, is mechanically controlled by means of variable speed drives. The clamps move laterally in two directions parallel to the plane of the sheet during stretching. A slow rate of stretch, $\frac{5}{8}$ inch per minute, was also used for this investigation. Stretching temperatures were controlled within ±1.7°C (±3°F) in the stretching machine. The material was preheated in an oven and quickly transferred to the stretching machine in which the stretching temperature was maintained. Several temperatures were used for stretching, as shown in the tables.

The data, which were obtained over a considerable period without a planned statistical experimental design, have been rigorously examined for homogeneity. This is a primary requisite for pooling data to be used in statistical tests. Some of the data did not meet this requirement and had to be abandoned. The statistical methods used are those for small samples, the degrees of freedom being one less than the number of observations.

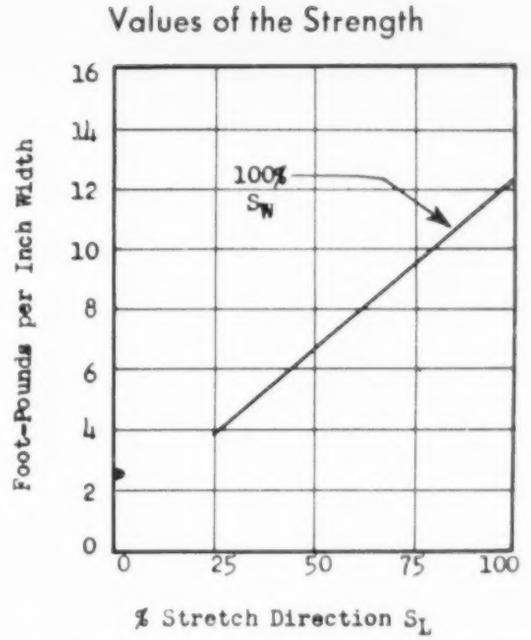


Figure 8. Unnotched Izod impact strength of biaxially stretched acrylic. Beams tested with long axis parallel to S (sub 1).

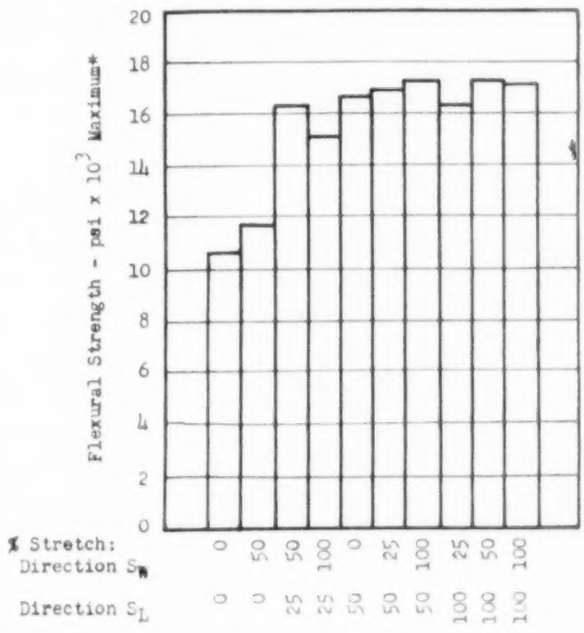


Figure 9. Notch sensitivity of biaxially stretched acrylic MIL-P-5425-A material. Beams tested with long axis parallel to S (sub 1).

TABLE I

TABULATION OF STATISTICS ON dW/dA VALUES FOR MIL-P-5425A MATERIAL STRETCHED 100%

Sheet Number	Stretch Temp. °C	Mean dW/dA Value $\bar{X}$	Sum of Squares Σx^2	D.F. n-1	Variance S^2	Standard Deviation S	Coeff. of Variation %	Comments
2-87	156	30.04	24.49	4	6.13	2.48	8.26	
2-88	156	27.56	36.49	2	18.24	4.27	15.5	Warm formed
2-95	156	31.20	83.60	4	20.9	4.57	14.7	
2-83	150	29.14	93.27	4	23.32	4.83	16.6	
2-84	150	25.22	43.93	4	10.98	3.31	13.1	
2-76	144	29.22	36.03	4	9.01	3.00	10.3	
2-77	144	32.68	73.75	4	18.43	4.29	13.1	Warm formed
2-75	144	29.84	78.27	4	19.57	4.42	14.8	
2-97	144	24.28	29.75	3	9.92	3.15	12.9	
2-138	135	33.42	68.91	4	17.23	4.15	12.4	
2-91	132	19.45	33.55	3	11.18	3.34	17.2	
2-94	132	22.44	37.08	4	9.27	3.04	13.6	Slow rate of stretch
Totals			639.12	44	173.37		$N = \sum_{1}^{N}(n-1) + 12 = 56$	

Grand mean = $\bar{\bar{X}} = 27.9$
Mean sample variance = $\bar{S}^2 = 14.5$
Neyman & Pearson L_o test for homogeneity of means and variances
$L_o = 0.4875$ 5% value for $L_o = 0.485$ (estimated)
This indicates that the means and variances do not differ significantly -- the data are homogeneous.

TABLE II

TABULATION OF STATISTICS ON dW/dA VALUES FOR MIL-P-5425A MATERIAL STRETCHED 73%

Sheet Number	Stretch Temp. °C	Mean dW/dA Value $\bar{X}$	Sum of Squares Σx^2	D.F. n-1	Variance S^2	Standard Deviation S	Coeff. of Variation %	Comments
2-37	144	34.52	20.71	3	6.90	2.63	12.7	
2-32	138	33.52	49.75	4	12.44	3.53	10.5	Slow rate of stretch
2-34	138	36.56	56.81	4	14.20	3.77	10.3	
2-39	132	31.78	40.51	4	10.13	3.18	10.0	Slow rate of stretch
2-42	132	33.78	43.59	4	10.89	3.30	9.8	
2-45	132	31.86	59.83	4	14.95	3.86	12.1	
2-40	126	31.56	23.19	4	9.64	2.41	7.6	
2-33	126	27.02	29.31	4	7.33	2.69	9.9	Slow rate of stretch
2-44	126	31.72	113.35	4	28.34	5.32	16.8	
Totals			437	35				

Grand mean = $\bar{\bar{X}} = 32.5$
Mean sample variance = $\bar{S}^2 = 12.5$
Neyman & Pearson L_o test for homogeneity of means and variances
$L_o = 0.6791$ 5% value for $L_o = 0.37$ (estimated)
This indicates that the means and variances do not differ significantly -- the data are homogeneous.

The grand means (X) of the dW/dA values for the three degrees of stretch are:

Percent Stretch	dW/dA Value Grand Mean
40%	9.7
73%	32.5
100%	27.9

The coefficient of variation for samples stretched 100%, 73%, and 40% are shown in the tables. This is the standard deviation expressed as a percentage of the mean.

Coefficient of variation = $S/\bar{X} \times 100$

Comparison of the relative variation in dW/dA values for the three degrees of stretch show 40% stretch has much higher values (greater variability) than is the case for either 73% or 100% stretch. It appears that the normal range in which the coefficient of variation can be expected for 73% and 100% stretch is between 10.0% and 17.0%. This range is normal for many materials.

These data show very significantly higher crack propagation resistance of MIL-P-5425A material stretched 73% and 100% than that for 40% stretch. The unstretched material has dW/dA value approximately equal to 5.0.

Confidence Limits for dW/dA Average Values

The 95% and 99% confidence limits for material

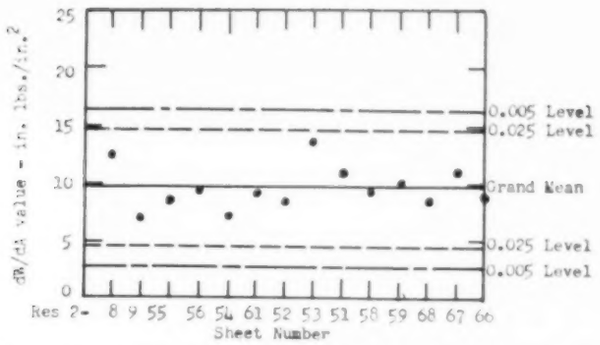


Figure 10. Ninety-five percent and ninety-nine percent confidence limits within which the population values for 40 percent stretched MIL-P-5425-A material can be expected to lie.

with the three degrees of stretch are shown in Figures 10, 11, and 12. These confidence limits are for five observations per sample. Increasing the sample size and or increasing the number of observations per sample will cause the confidence limits to converge more closely on the true unknown value. When more data are available, new confidence limits, within which lie 95% or 99% of the average dW/dA values, may need to be determined.

The measures of reliability for determining these limits are based on the standard deviation calculated from samples belonging to populations having means and variances that are homogeneous. The Normal Law integral diagram gives the factors "t" for use in formula $\bar{X} \pm ts$ for the 95% and 99% confidence limits. (15) The method is as follows:

1. Calculate the mean sample variance ($\bar{S}^2$) for all samples.
2. Obtain unbiased estimate of standard deviation, $S = (\bar{S}^2)^{1/2}$
3. 95% limits are $\bar{X} \pm 1.96S$ from Grand Mean $\bar{X}$.

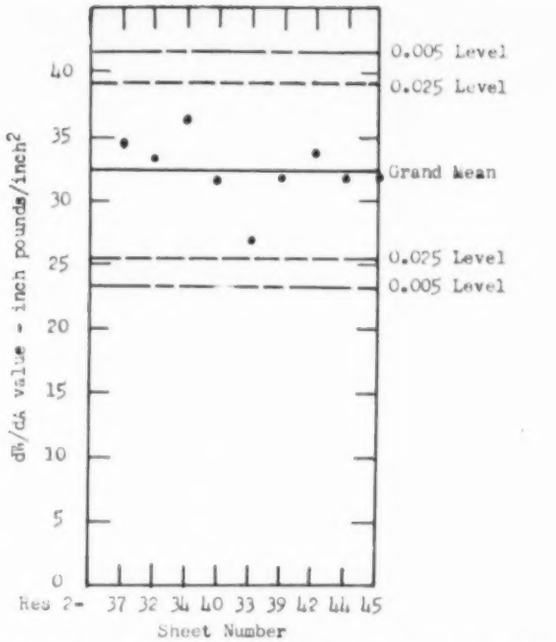


Figure 11. Ninety-five percent and ninety-nine percent confidence limits within which the population values for 73 percent stretched MIL-P-5425-A material can be expected to lie.

4. 99% limits are $\bar{X} \pm 2.58S$ from Grand Mean $\bar{X}$.

Sample calculation:

for 100% stretch:

$\bar{S}^2 = 14.5$; $S = 3.8$

Grand Mean $\bar{X} = 27.9$

95% confidence limits:

$L_1 = 27.9 - 1.96 \times 3.8 = 20.5$

$L_2 = 27.9 + 1.96 \times 3.8 = 35.4$

TABLE III

TABULATION OF STATISTICS ON dW/dA VALUES FOR MIL-P-5425A MATERIAL STRETCHED 40%

Sheet Number	Stretch Temp. °C	Mean dW/dA Value $\bar{X}$	Sum of Squares Σx^2	D.F. n-1	Variance S^2	Standard Deviation S	Coeff. of Variation %	Comments
2-9	144	7.10	5.54	4	1.39	1.18	16.5	
2-53	144	13.62	5.58	4	1.39	1.18	8.7	
2-54	138	7.22	12.09	4	3.02	1.74	24.1	
2-61	138	9.12	14.73	4	3.69	1.92	10.1	
2-66	138	9.14	49.15	4	12.29	3.51	38.4	Slow rate of stretch
2-55	132	8.56	19.68	4	4.92	2.22	25.9	
2-56	132	9.26	10.48	4	2.62	1.62	17.5	
2-8	132	12.4	27.12	4	6.78	2.60	21.0	
2-67	132	10.9	35.27	4	8.82	2.97	56.1	Slow rate of stretch
2-52	126	8.54	31.65	4	7.91	2.81	32.9	
2-68	126	8.6	27.70	4	6.93	2.63	30.6	Slow rate of stretch
2-51	120	10.9	21.71	4	5.43	2.33	21.4	
2-58	120	9.7	99.11	4	24.78	4.98	51.3	
2-59	120	10.12	18.55	4	4.64	2.15	21.2	Slow rate of stretch
Totals			378.36	56			N = 70	

Grand mean = $\bar{\bar{X}} = 9.7$

Mean sample variance = $\bar{S}^2 = 6.76$

Neyman & Pearson L_0 test for homogeneity of means and variances

$L_0 = 0.6014$ 95% value for $L_0 = 0.5$ (estimated)

This indicates that the means and variances do not differ significantly -- the data are homogeneous.

99% confidence limits:

$1_1 = 27.9 - 2.58 \times 3.8 = 18.1$

$1_2 = 27.9 + 2.58 \times 3.8 = 37.7$

The true unknown average of the population of individual measurements will be included between these confidence limits within the probability of 0.95 or 0.99. Averages of small samples of measurements are plotted rather than individual values because in practice the points jump around in about the same way under conditions of statistical control, regardless of how the individual measurements behave under these conditions.

Statistical Analysis of dW/dA Data

Test for Homogeneity of Data

In order to make valid deductions from statistical analyses of data, it is first necessary to know that variation in the values of a characteristic, such as the dW/dA values, is the result of chance causes. The data are then said to be statistically uniform or homogeneous. This is a requirement which must be met in order to pool information for further analysis. The dW/dA data were tested

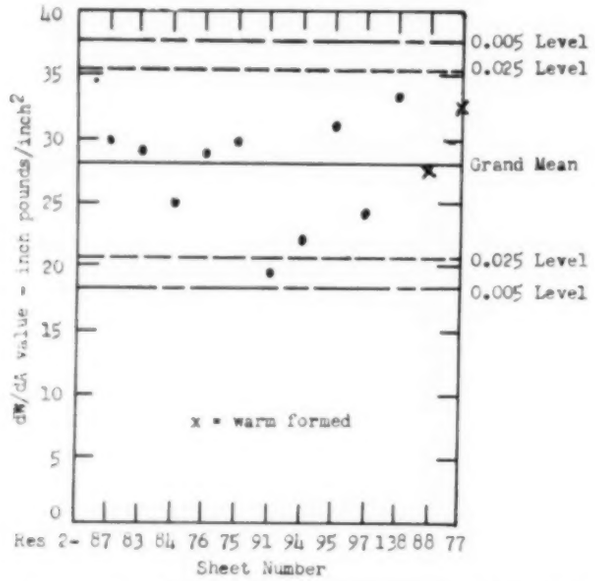


Figure 12. Ninety-five and ninety-nine percent confidence limits within which the population values for 100 percent stretched MIL-P-5425-A material can be expected to lie.

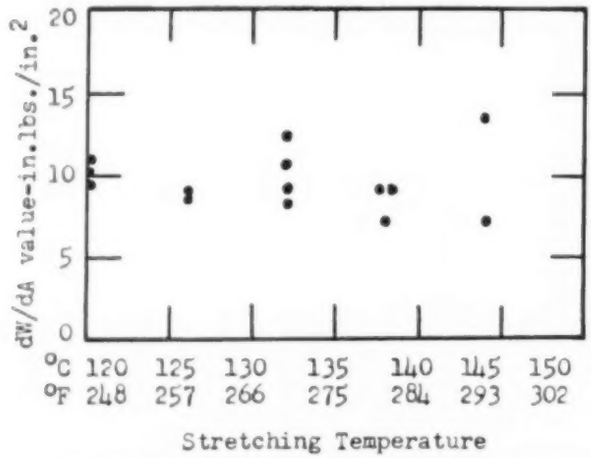


Figure 13. Plot of dw/da values for MIL-P-5425-A material stretched 40 percent at various temperatures.

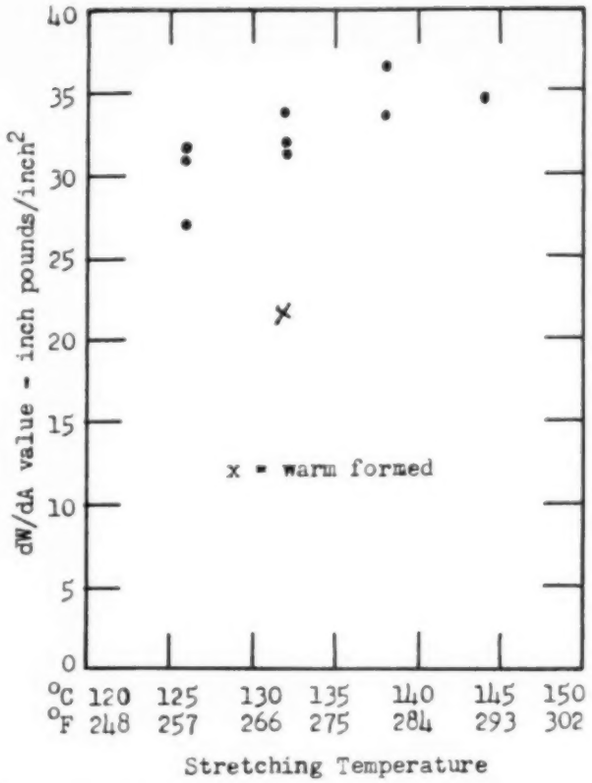

dW/dA value - inch pounds/inch²
x = warm formed
°C 120 125 130 135 140 145 150
°F 248 257 266 275 284 293 302
Stretching Temperature

Figure 14. Plot of dw/da values for MIL-P-5425-A material stretched 73 percent at various temperatures.

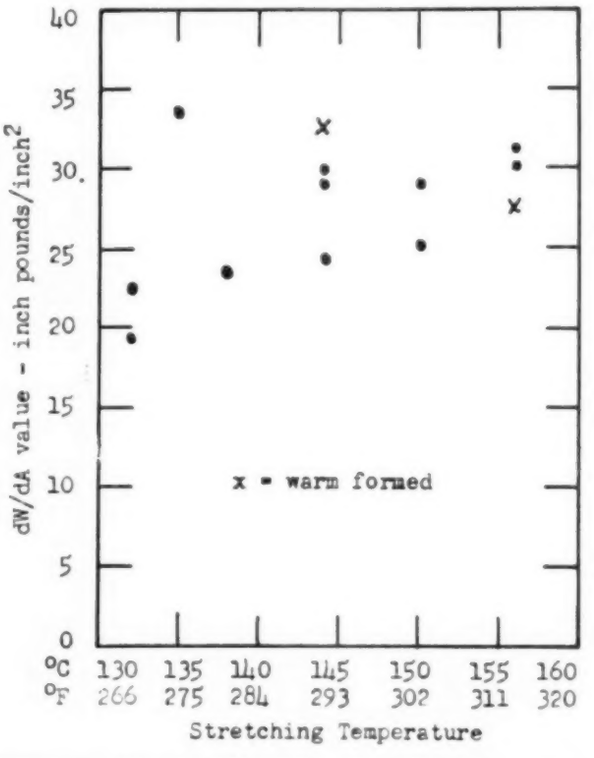

dW/dA value - inch pounds/inch²
x = warm formed
°C 130 135 140 145 150 155 160
°F 266 275 284 293 302 311 320
Stretching Temperature

Figure 15. Plot of dw/da values for MIL-P-5425-A material stretched 100 percent at various temperatures.

for homogeneity of means and of variances by the Neyman and Pearson L_ω test described in Appendix I. Data in Tables I, II, and III for 100%, 73%, and 40% stretch respectively, meet the requirements of this test for homogeneity. The data are plotted in the scatter diagrams shown in Figures 13, 14, and 15 for the three degrees of stretch.

Tests for Trends in Data

It is desirable to determine whether a trend exists in each of the sets of means in the three groups. The mean squared successive difference, or δ^2 test, described in Appendix II, is used. This test, applied to the data in Figure 13 for 40% stretch, shows that the data jump around in a random manner and no trend exists.

The results of the δ^2 test on data in Figure 14 for 73% stretch show that they can be represented by a smooth curve with non-vanishing slope. The estimating equation for the least square line representing these data has a slope which does not differ significantly from zero (Appendix II). This indicates no significant effect of the stretching temperature upon the dW/dA values for material stretched 73% under these conditions.

The δ^2 test, applied to the data in Figure 15 for 100% stretch, shows that a horizontal straight line can be drawn to represent them.

Analysis of Variance

The analysis of variance for all three degrees of stretch shows that the dW/dA values are not affected significantly by either the stretching temperature or the rate of stretching. The interaction term in the analysis of variance is a measure of the influence of one factor (stretching temperature) on the effect of the other factor (stretching rate). (17, 18) If stretching temperature and stretching time produce their effects independently, there is no interaction. Under the conditions used for stretching, there was no interaction between these two factors (Appendix III).

In the analysis of variance for 100% stretch, the effect of a simulated warm forming cycle on the dW/dA values was tested. The stretched sheets were held thirty minutes at 105°C (221°F) to simulate a temperature and time condition which might be used for warm forming. The results of the statistical analysis showed no significant effect of a simulated warm cycle upon the dW/dA values for 100% stretch (Appendix III).

Conclusion

Stretched acrylic material has properties which appear to make it satisfactory for use in applications such as aircraft canopies. The considerable improvement in resistance to crack propagation and resistance to crazing of biaxially stretch oriented acrylics is a distinct advantage as compared to unstretched material. There is some improvement in the notch sensitivity and impact strength properties as the result of stretching.

The dW/dA values are not significantly affected by rates of stretching up to 2½ inches per minute, by temperature of stretch at these rates, or by a simulated warm forming cycle. Before these conclusions regarding effects of stretching conditions can be extended to a more general statement for wide choice of conditions, it is necessary to obtain more data. Plans are being considered for investigations on material stretched at higher rates under other conditions.

I wish to express appreciation for permission granted by the Materials Laboratory, Wright Air Development Command, to present these data.

Appendix I

Test for Homogeneity of Means and Variances

The Neyman and Pearson L_ω test is used to determine whether the samples belong to normal populations having the same mean and the same variance. (14) This test is based on the sample variances. It is known that two independent estimates of the variance can be obtained which differ significantly only if the sample means differ significantly among themselves. Neyman and Pearson also devised the L_0 test for homogeneity of variance. If the hypothesis that the data do belong to the specified population is true, the value of L tends to unity. Tables are available for the distributions of L_0 and L_ω showing the values which must be exceeded at 5% and 1% levels in order for the hypothesis not to be discredited.

$$L_\omega = \frac{\left(s_1^2 \cdot s_2^2 \cdots s_k^2\right)^{1/k}}{s_\omega^2}$$

where S_1^2 . S_2^2 . . . S(sub k)^2 are the sample variances. S_ω^2 is variance based on the deviations of all n observations about their mean.

$$S_\omega^2 = \frac{\sum_1^{nk} (x - \bar{x})^2}{N}, \quad N = nk$$

k = number of samples

The value of L_0 is computed by means of logarithms using the geometric mean variance S(sub g)^2

$$S(\text{sub g})^2 = (S_1^2 \cdot S_2^2 \cdot \ldots S(\text{sub k})^2)1/k$$

taking logs

$$\log L_0 = \log S(\text{sub g})^2 - \log S_\omega^2$$

Appendix II

δ^2 Test for Trends among the dW/dA Means

This is an independent test and can be run without being preceded by the L_ω, or F test, but technically presupposes the L_0 test. The ratio of δ^2 to S^2 is computed and compared with significance levels which have been computed. (16) If no trend exists, the expected value of δ^2/S^2 is 2 and the data may then be represented by a horizontal straight line. A value significantly lower than 2 indicates some sort of a smooth trend which can be represented by a continuous curve with non-vanishing slope. If the data tend to oscillate by large jumps between consecutive items, then δ^2 will be large relative to S^2, and the value of δ^2/S^2 will be greater than 2.

If the population is shifting, the usual estimate of variance

$$S^2 = \sum_1^n (\bar{x}_i - \bar{\bar{x}})^2 / (k-1)$$

where

$$\bar{\bar{x}} = \frac{\Sigma \bar{x}_i}{n}$$

will include the effect of the shift. A valid estimate of the unassignable variance is $1/2\ \delta^2$, where

$$\delta^2 = \Sigma (\bar{x}_{i+1} - \bar{x}_i)^2 / (k-1)$$

The δ^2 test is the ratio

$$\frac{\delta^2}{s^2} = \frac{\Sigma (\bar{x}_{i+1} - \bar{x}_i)^2 / k-1}{\Sigma (\bar{x}_i - \bar{\bar{x}})^2 / k-1} = \frac{\Sigma (\bar{x}_{i+1} - \bar{x}_i)^2}{\Sigma (\bar{x}_i - \bar{\bar{x}})^2}$$

$$\Sigma (\bar{x}_{i+1} - \bar{x}_i)^2 = 2\Sigma \bar{x}_i^2 - \bar{x}_1^2 - \bar{x}_n^2 - 2\Sigma \bar{x}_i \bar{x}_{i+1}$$

$$\Sigma(\bar{X}_i - \bar{\bar{X}})^2 = \Sigma \bar{X}_i^2 - \frac{(\Sigma \bar{X}_i)^2}{k}$$

X_i = individual means

We wish to test whether the consecutive dW/dA mean values for different temperatures of stretching show a relationship or whether they vary in a random manner. In case of unequal numbers of sample means X(sub i), for each value of the independent variable (stretching temperature), the average of the sample means is used in calculating the δ^2/S^2 values. Otherwise, errors would result from lack of symmetry and excessive weighting of some of the independent variables (stretching temperature). The data for 40% stretch are:

Stretching Temp. °C	Sample Means X(sub i)				Average of Means X(sub ai)
120	9.7	10.9	10.1	——	10.2
126	8.5	8.6	——	——	8.5
132	12.36	10.9	8.56	9.26	10.3
138	7.22	9.12	9.14	——	8.5
144	7.16	13.62	——	——	10.4

δ^2 test—

$$\Sigma(\bar{X}_{ai+1} - \bar{X}_{ai})^2 = 2\Sigma \bar{X}_{ai}^2 - \bar{X}_1^2 - \bar{X}_n^2 - 2\Sigma \bar{X}_{ai}\bar{X}_{ai+1}$$

$$= 925.58 - 464.04 - 458.16 - 700.4 = 12.98$$

$$\Sigma(\bar{X}_{ai} - \bar{\bar{X}})^2 = \Sigma \bar{X}_{ai}^2 - \frac{(\Sigma \bar{X}_{ai})^2}{k}$$

$$= 462.79 - 458.88 = 3.91$$

$k = 5$

$\delta^2/S^2 = 12.98/3.91 = 3.32$

From table, value for P = 0.95 is 3.1796
value for P = 0.99 is 3.4621

The value 3.32 is significant at the 0.95 level. This indicates random jumping around of the data with no definite relationship.

The data for 73% stretch are:

Stretching Temp. °C	Sample Means X(sub i)			Average of Means X(sub ai)
126	31.56	27.02	31.72	30.1
132	31.78	33.78	31.86	32.5
138	33.52	36.56	——	35.0
144	34.5	——	——	34.5

$$\Sigma(\bar{X}_{ai+1} - \bar{X}_{ai})^2 = 8625 - 906 - 1190 - 6647 = -18$$

$$\Sigma(\bar{X}_{ai} - \bar{\bar{X}})^2 = 4,312 - 4,363 = -51$$

$\delta^2/S^2 = -18/-51 = 0.3529$

For k = 4, table value for P = .001 is 0.5898

Since the value 0.3529 is very significantly lower than 2, there is a relationship between stretching temperature and dW/dA values for 73% stretch and the data follow a smooth curve with non-vanishing slope.

The estimating equation is based on the four dW/dA values that are averages of the means:

$Y^1 = -6.25 + 0.291X$

$Y^1 + 6.25 = 0.291X$

The regression coefficient 0.291 measures the average amount of increase in Y per unit increase in X.

Student's t Test is used to determine whether the regression coefficient, b, for 73% stretch is significantly different from zero. (19)

$$t = \frac{b - \beta}{S_b}$$

where S(sub b) is the estimate of the standard deviation of b

$$S_b = \left[\frac{\Sigma(Y - Y^1)^2}{(N-2)\Sigma(X - \bar{X})^2}\right]^{1/2}$$

The null hypothesis is set up with a hypothetical value β equal to zero.

$$t = \frac{0.291 - 0}{\left[\frac{15}{360}\right]^{1/2}} = \frac{.291}{204} = 1.426$$

For 2 degrees of freedom

P = 0.05, the table value of t = 4.303
P = 0.01, the table value of t = 9.25

This test indicates that the slope (b) does not differ significantly from zero, indicating that stretching temperature has no significant effect upon dW/dA values of material stretched 73% under these conditions.

The data for 100% stretch are:

Stretching Temp. °C	Sample Means X(sub i)				Average of Means X(sub ai)
132	19.45	22.14	——	——	20.8
135	33.42	——	——	——	33.4
144	24.28	29.84	32.68	29.22	29.0
150	25.22	29.14	——	——	27.2
156	31.20	27.56	30.04	——	29.6

δ^2 test

$$\Sigma(\bar{X}_{ai+1} - \bar{X}_{ai})^2 = 2\Sigma \bar{X}_{ai}^2 - \bar{X}_1^2 - \bar{X}_n^2 - 2\Sigma \bar{X}_{ai}\bar{X}_{ai+1}$$

$$= 8010 - 433 - 876 - 6520 = 181$$

$$\Sigma(\bar{X}_{ai} - \bar{\bar{X}}_{ai})^2 = \Sigma \bar{X}_{ai}^2 - \frac{(\Sigma \bar{X}_{ai})^2}{k}$$

$$= 4005 - 3920 = 85$$

$$\frac{\delta^2}{S^2} = \frac{181}{85} = 2.1294$$

Entering the table with k = 5

P = 0.05 ; $\delta^2/S^2 = 0.8204$
P = 0.95 ; $\delta^2/S^2 = 3.1796$

Since 2.1294 is between these two levels of significance, the dW/dA data in Figure 15 may be represented by a horizontal straight line.

The estimating equation for this line, calculated by least squares of the five sets of data, is:

$Y^1 = 9.6 + 0.129X$

Appendix III

Analysis of Variance

The variances of the individual means are pooled to obtain an unbiased estimate of the uncontrolled error component, according to the formula: (17, 26)

uncontrolled error = S^2(sub e)

$= 1/k\,[S_1^2/r_1 + S_2^2/r_2 \ldots + S^2\,(\text{sub k})/r\,(\text{sub k})]$

where S_1^2, $S_2^2 + \ldots + S(\text{sub k})^2$ are the individual variances and r_1, $r_2 + \ldots + r(\text{sub k})$ are the number of replications.

The uncontrolled error is used as the base for comparison in the analysis of variance. The degrees of freedom for the uncontrolled error is (N − 1) times the number of samples, where

N = number of observations per sample.

The interaction term in the analysis of variance is obtained as the difference between the total sum of squares of the deviations of all average values about their grand mean and the combined sum of squares for between

columns (stretching rate) and between rows (stretching temperature). (17) The degree of freedom for interaction is $(r - 1)(c - 1)$,

where r = number of rows

c = number of columns

Data for analysis of variance for 40% stretch are given in Table IV.

TABLE IV

Data for Analysis of Variance for 40% Stretch
dW/dA values are average of means for samples.

Stretching Temp. °C	Stretching Rate 2½"/min.	Stretching Rate ⅝"/min.	Row Total
120	10.3	10.1	20.4
126	8.5	8.6	17.1
132	10.1	10.9	21.0
138	8.2	9.1	17.3
Column Total	37.1	38.7	75.8

The uncontrolled error calculated from data in Table III is—

$$\hat{S}_e^2 = \frac{1}{12}\left(\frac{3.02+3.69}{2} + \frac{12.29}{1} + \frac{4.92+2.02+0.78}{3} + \frac{8.82}{1} + \frac{7.91}{1} + \frac{6.93}{1} + \frac{5.43+24.78}{2} + \frac{4.64}{1}\right) = 5.32$$

Total Sum of Squares is given by

$$\Sigma X^2 = \Sigma X^2 - (\Sigma X)^2/N$$

$$\Sigma X^2 = 725 - (75.8)^2/8 = 7$$

Sum of squares between rows

$$= \frac{\sum_1^{k_r}\left(\frac{N_r}{\Sigma X}\right)^2}{N_r} - \frac{(\Sigma X)^2}{N} = \frac{1448}{2} - 718 = 6$$

Sum of squares between columns

$$= \frac{\sum_1^{k_c}\left(\frac{N_c}{\Sigma X}\right)^2}{N_c} - \frac{(\Sigma X)^2}{N}$$

Interaction = 7 − (6 + 0.5) = 0.5

Table V is the summary of computations for analysis of variance for material stretched 40%.

TABLE V

Summary of Computations for Analysis of Variance for 40% Stretch

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Variance Ratio "F"
Between columns	0.50	1	0.50	0.094*
Between rows	6.0	3	2.0	0.376*
Interaction	0.50	3	0.166	0.031*
Error	——	48	5.32	

*Not Significant

Data for analysis of variance for 73% stretch are given in Table VI.

TABLE VI

Data for Analysis of Variance for 73% Stretch
dW/dA values are average of sample means.

Stretching Temp. °C	Stretching Rate 2½"/min.	Stretching Rate ⅝"/min.	Row Total
126	31.6	27.0	58.7
132	32.8	31.8	64.6
138	36.6	33.5	70.1
Column Total	101.0	92.3	193.4

The uncontrolled error calculated from the variances in Table II is—

$$\hat{S}_e^2 = \frac{1}{8}\left(\frac{12.44}{1} + \frac{14.20}{1} + \frac{10.13}{1} + \frac{10.89+14.95}{2} + \frac{9.04+28.34}{2} + \frac{7.33}{1}\right) = 9.50$$

The summary of the computations for analysis of variance for 73% stretch is given in Table VII.

TABLE VII

Summary of Computations for Analysis of Variance for 73% Stretch

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Variance Ratio "F"
Between columns	16.0	1	16.0	1.67*
Between rows	35.5	2	17.8	1.85*
Interaction	22.5	2	1.5	0.16*
Error	——	32	9.5	

*Not Significant

In the analysis of variance for 100% stretch, the effect of simulated warm forming condition on the dW/dA values was tested. The data are shown in Table VIII.

TABLE VIII

Data for Analysis of Variance for 100% Stretch
dW/dA values are average of sample means.

Stretching Temp. °C	Treatment As Stretched	dW/dA Simulated Warm Formed	dW/dA Value Row Total
144	27.8	32.7	60.5
156	30.6	27.6	58.2
Column Total	58.4	60.3	118.7

Total sum of squares = 3540 − ¼(118.7)² = 3540 − 3522 = 18

Sum of squares between columns = ½ x 7047 − 3522 = 1.5

Sum of squares between rows = ½ x 7047 − 3522 = 1.5

Interaction = 18 − (1.5 + 1.5) = 15

From Table I, the degrees of freedom for error = 25

Also from Table I, the uncontrolled error is—

$$\hat{S}_e^2 = \frac{1}{7}\left(\frac{6.13+20.9}{2} + \frac{18.24}{1} + \frac{9.01+19.57+9.92}{3} + \frac{18.43}{1}\right) = 9.00$$

The summary of computations for analysis of variance for 100% stretch is contained in Table IX.

Summary of Computations for Analysis of Variance for 100% Stretch

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	Variance Ratio "F"
Between columns	1.5	1	1.3	0.17*
Between rows	1.5	1	1.5	0.17*
Interaction	15.0	1	15.0	1.7*
Error	——	25	9.0	

*Not Significant

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(Please turn to page 35)

Definitive Specifications for Plastics Materials

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THE SELECTION OF proper materials of construction becomes increasingly important as performance requirements become more critical. Once the best material is selected, whether on the basis of past experience, experimental evaluation or by actual service test, it is essential that this identical material continue to be used if predicted performance is to be realized. Consequently the precision molders of today require, and must insist, that materials used in industrial applications maintain a uniform level of quality and exhibit a dependable, reproducible fabricating behavior, day after day and year after year.

In an effort to assure satisfactory performance of finished plastic parts more and more industrial firms are purchasing such parts on a specification basis. This has long been a practice of the military services. This trend toward specification purchasing is a good one and the whole industry will profit from it, provided the specifications are meaningful and actually accomplish their intended purpose.

Typical material specifications in many fields, such as the steel industry, are relatively simple documents. They state in clear and concise language the requirements of the purchaser in terms of identification of the desired commodity and the quality level that will be acceptable. Such specifications are purely a statement of acceptable conditions of procurement and make no pretense of any other function.

Writing Specifications

In the writing of specifications for the purchase of plastics, however, there is sometimes a tendency to lose sight of the true intent of the document and make it fulfill the role of an engineering manual. As a result it is neither a definitive basis for procurement nor an adequate source of engineering information.

Realizing that physical properties alone do a very poor job of identifying a material or establishing its quality, the natural tendency is to incorporate every possible physical test whether pertinent or not in an attempt to provide adequate coverage. In fact many of the tests used are actually misleading.

With all plastic materials the physical property measurements on molded specimens vary widely as a result of fabricating conditions and the environment to which they have been exposed prior to testing. As a result the values obtained do not necessarily reflect the quality of the original polymer. Performance of plastic moldings is also greatly influenced by their configuration. Values obtained from a standard test bar are merely indicative of what is to be expected from a molding of another shape.

This article is a slightly condensed version of the paper presented at the 12th SPE Conference.

In view of this it would seem preferable to have separate specifications for the basic polymer and for parts fabricated from this polymer. Sometimes this is not entirely feasible and it becomes necessary to incorporate both in a single document. In this case the specification should be written in two distinct parts, one to characterize the basic polymer by means of suitable tests on the virgin resin, the second to define the acceptable limits of change resulting from the fabrication procedure.

It should be the objective of the first part of the specification, dealing with the basic polymer, to distinguish the material from any possible substitute, to detect any degradation or contamination and to establish that it will have proper processing characteristics.

Changes in Properties

It should be the objective of the second part of the specification to detect any degradation or change in properties from those of the virgin resin, as a result of processing conditions.

In each case, the specified tests should be the fewest number possible to insure confidence in the adequacy of the specification coverage. Wherever possible, tests should be selected that are independent of the influence of environment on the specimens.

Where finished moldings are being purchased it will usually be necessary to supplement the coverage of a general specification by detailing the specific requirements for the application in question. For noncritical uses a simple statement of the dimensional tolerances required may be all that is necessary to insure proper performance. In more complex situations involving severe conditions of service and unusual or extreme environments, it may be essential to employ performance tests specially designed for the purpose to insure that a sufficiently high level of quality will be maintained to insure expected performance. Performance requirements should be covered in an agreement between the vendor and purchaser, relating to a specific molding, rather than to attempt to provide such detailed coverage within the framework of a broad specification designed for general use.

The development of specialized performance tests to measure the quality of finished components in terms of actual service requirements is a subject much too involved to discuss within the confines of this paper. We will, therefore, limit our discussion to the basic tests useful for material specification purposes.

You are already aware of a very simple system that correctly designates the many different kinds of polyethylene. Thus wide differences in polymer structure are revealed by the simple measurements of density and melt index. Likewise, the many types of nylons may be distinguished by similar simple tests. Table A shows how these tests differentiate among the several commercially

available nylons. They have widely different melting points and in most cases this test alone will identify the nylon. When the melting point ranges of two overlap somewhat this case of identity is readily resolved by specific gravity measurement.

Having established the identity of the material, the next essential purpose of the specifications is to assure that the nylon is adequate in quality and processing characteristics. The first test for quality is visual inspection for color and contamination. It is usually adequate for most purposes. In polymers, adequate molecular weight is essential for good physical properties. This is the second measure of quality that must be obtained; accordingly a minimum relative viscosity is established. To assure reproducible processing properties in nylon the molecular weight variation must not be too broad, so a maximum relative viscosity is also established. In addition, a maximum water content and a good "cut" are established by moisture analysis and a count of "longs" in the granulation.

We believe that these few tests will assure the purchaser of a nylon molding powder that he has received what he has ordered. The tests are few and simple. These are, of course, not the only tests to measure these same properties and some of the more powerful tools of the polymer chemist might be called upon for referee purposes.

Customer Assurance

The steps just described tell the purchaser whether the quality of the molding powder is satisfactory. Now a customer—the purchaser of the fabricated article—wants to assure himself that this quality has been maintained during fabrication. Of course, he is not concerned about processing characteristics, so the moisture content and granulation tests do not apply. However, he can identify the nylon by use of melting point and specific gravity tests and he can establish its quality by a visual examination for color and contamination and by relative viscosity measurements for minimum molecular weight. These quality tests will assure him that no chemical or hydrolytic degradation of the nylon has occurred during fabrication to cause a change in polymer structure or loss in molecular weight that would produce a product of inferior properties.

To illustrate how this approach has been applied to a specific problem we show in Tables I, II, and III a portion of a military specification covering a specific weather-resistant grade of polyamide nylon plastic. This will illustrate the suggestions we have outlined. Only eight tests as shown in Table I are necessary to characterize the material covered by this specification. The melting point and specific gravity positively identify the polymer. The allowable relative viscosity range gives assurance that the polymer has the correct molecular weight for optimum processability and adequate physical properties. Since this grade of nylon is a special purpose composition that must perform a function beyond that expected of the base resin, special tests aimed at the differences are added. Thus solution light transmission requirements together with the limits imposed on carbon content attest to the adequacy of pigment dispersion and consequently the weatherability of the polymer. Moisture content, granulation and contamination limits assure good processability of the product.

None of these tests requires the molding of special shapes. They are all performed on the basic polymer in granular form; thus no uncertainties are introduced by superimposing vagaries of fabrication and physical testing on the essential properties of the polymer. Time-consuming molding and conditioning of samples are eliminated.

Having established the identity and quality of the polymer, only four tests as as given in Table II are needed to give assurance that no degradation has resulted from the molding, extrusion, or other fabrication procedures to which the polymer may have been subjected in the production of a finished article. The minimum limit for relative viscosity gives assurance that the polymer has not been degraded by having been processed in the presence of excess moisture or at too high temperature. The specific gravity range and melting point serve to identify the polymer. The mandrel bend test measures the toughness of the material after molding, and so detects gross contamination that would be hidden by the carbon black. This is in a sense a substitute test for visual examination used with natural-color nylons.

Eight different tests are needed. References are shown in Table III.

This is a very simple yet realistic approach to the problem of securing adequate specification coverage for plastic materials. We believe that this approach results in a definitive, practical, and simple document that will protect both the purchaser and the vendor and will assure a dependable supply of dependable material.

(Please turn to page 58)

A Proposed Specification

Table I
Physical Requirements

PROPERTY	REQUIREMENT
Melt Point °F Min.	480
Specific gravity	1.13-1.15
Relative Viscosity Range	48 Min. 60 Max.
Solution Light Transmission (Absorbency 1 cm. Cell)	0.180% Min.
Carbon Content Range	1.90% Min. 2.25% Max.
Moisture Content	0.31% Max.
Granulation (Number of Longs over ½" per 8 oz. sample)	6 Max.
Contamination — Non-Black Cubes (Number per 8 oz. sample)	None

Table A

Test ("Zytel" Nylon Resin Code)	Composition (101)	(31-33)	(61)	(69)	(211)
Melt Point °C. ASTM D789-53T	250-260	208-220	148-160	140-153	196-223
Relative Viscosity ASTM D789-53T	49-57	28-34	75-95	60-87	70-100
Specific Gravity ASTM D792-48T	1.13-1.15	1.07-1.09	1.08-1.10	1.07-1.09	1.12-1.14

Injection Molding Research

Today and Tomorrow

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INJECTION MOLDING RESEARCH has been rolling during the past several years. Technology and polymer advances have been many and of great value. In spite of the progress it appears there is a considerable amount of ground which must be covered and numerous byways to be investigated before this method of fabrication can be considered to have a mature technology.

Much of the research information which has appeared has been published in fragmentary form as it became available without much opportunity to establish its proper position in a systematic technology. We decided to discuss existing information and vacancies in the system in the order of progress of the plastic through the injection molding machine. Much of the data we will discuss was obtained from work with polystyrene, but the basic concepts described apply to all thermoplastics.

Method of Feeding Material Into The Heating Cylinder

The purpose of measuring the granule feed is to control the amount of material which is forced into the mold. Variations in the finished product depend upon the accuracy of the feeding system.

Compressibility data for polystyrene has been used to calculate the effect of varying volume of material in the mold cavity (1, 2, 3, 4). A change of .5% in the weight of the mold charge for a sixteen ounce shot results in a pressure difference of 1400 psi. within the cavity. If nothing else varies except the feed, this calculation indicates that the pressure difference inside the cavity can be a total of 2800 psi. The effects of pressure variation in the mold have been discussed many times; crazing, warping, cracking, dimensional inaccuracy, heavy weight parts and mold deterioration are well known results (5, 6, 7, 8). Weigh feeding has been a forward step in improving precision molding operations, but we need to go considerably further (9, 10). Greater precision of control of preplasticized feed has been provided by mechanical limitation of the stroke of the shooting plunger as a corollary to weigh feeding of the conventional machine (11).

Thin wall and large area moldings, high speed injection and automatic operations require even greater precision than is now available. A pressure signal from the plasticized zone has been suggested as the next step in improvement of precision control of the amount of material which is placed in the mold cavity (11). This technique will aid in minimizing the effect of temperature, pressure and material variations in the heating cylinder. Several organizations are investigating this method of control. Several different schemes are being tried. Investigations in our own laboratories indicate this is a feasible method of adding a considerable amount of precision to injection molding control.

Effect of Granule Size, Shape and Treatment

In the early days of injection molding of polystyrene, granule size, shape and external lubrication were known to be effective aids in loading a capacity shot into a molding machine. There is much more known about these three factors today. Research has shown definite relationships between these three factors and friction heat, air entrainment, pressure transmission and heating rate (12, 13, 14). Material suppliers have spent a considerable amount of research effort to determine the effect of these factors on moldability and the quality of the molded part.

External lubrication reduces the pressure loss through the molding machine, allows the granules to compact better, eliminates friction burning and allows faster plunger travel (14). The limitations in the amount of external lubrication have been staked out. Figure I indicates the effect of external lubricant on the pressure loss in the nonfluid zone. Too little allows compaction of the granules but does not reduce the resistance forces between the granules and the wall. This increases the pressure loss. Additional lubricant reduces the pressure loss. However, there is a limit to the amount of lubricant which may be used for decreasing pressure loss. Beyond this limit only a short distance haze and streaking are encountered.

The size and shape of granules are important factors in compaction and air entrapment. If the granules are too large, air entrapment is likely to be a problem. When air is carried through the heating cylinder into the mold with polystyrene it becomes a major cause of silver streaking. When air is carried into the mold with polyethylene it becomes compressed air bubbles. Granules which are too small have been observed to melt quickly on the surface and be compacted in such a fashion as to trap the air within a plastic mass which will not release it until it is in the mold. The small granules have been found to be good for dry blend coloring because of their large surface to volume ratio (15).

The shape of the granules is also directly related to the flowability and the apparent density, or bulk factor. A wide variety of shapes have been used with good achievement of pourability, angle of repose and bulk factor. To sum it up, the shape is chiefly important in getting the material into the heating cylinder while the size and external lubrication affect the molding performance.

Uniformity of granulation is as important as size, shape and external lubricant. Granulations with wide ranges of size distribution have shown high pressure loss and poor temperature uniformity at the nozzle. Temperature variation of the plastic measured at the nozzle with uniform and nonuniform granulation is shown in Figure II.

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Nonfluid Zone

The pressure drop in the granules can be as much as eighty percent of the total pressure drop through the injection molding heating cylinder. This pressure loss is concentrated in a very short portion of the heating cylinder where unplasticized granules are in contact with the steel surfaces. As soon as melted plastic becomes available at the wall of the heater and the spreaders it becomes a fluid lubricant and the effects of external lubrication are no longer present at the wall. The amounts of external lubricant normally used are too small to act as an effective internal lubricant in the fluid zone. The design of this portion of the heating cylinder is extremely critical and several factors must be considered simultaneously at this point. From the pressure conservation standpoint it has been found advisable not to decrease the cross section area for plastic until the nonfluid zone is passed. Restrictions of cross sectional area are then in order. Many new designs of heating cylinders which we have seen have given much more consideration to the granular zone than has been given in the past.

To minimize granule-to-wall friction, it is considered advisable to maintain as high a heater wall and spreader surface temperature in the nonfluid zone as possible. However, the temperature in this zone should not be so high as to cause the granules to melt and trap air before they are compacted. It is necessary to provide room for the air to escape backward over the plunger in this zone so it will not be carried forward through the nozzle into the mold.

Fluid Zone

The fluid zone serves the purpose of completing the melting of the plastic granules and making the mass of melted plastic as uniform as possible in temperature. The heat transfer rate to the plastic depends upon the ratio of the square of the heating surface area divided by the volume. This ratio can be increased by three different methods; (1) decreasing the thickness, (2) increasing the length of the cylinder or, (3) increasing the heater body bore. Figure III illustrates the effects of these three variables. Decreasing the annular thickness and increasing the length of the cylinder increases the pressure loss. Increasing the heater body bore decreases the pressure loss.

Figure IV illustrates the effect of heating chamber geometry on the plasticizing capacity of the cylinder. Decreasing the thickness of the annulus is a poor way to improve the plasticizing capacity of a cylinder, because the pressure loss increases very rapidly. Increasing the length of the annulus is not a very good way to increase the plasticizing capacity of the cylinder for two reasons. The pressure drop increases with length and the greater length of plastic ahead of the plunger makes the plunger system considerably less rigid and results in poor pressure control in the mold. If a given annular thickness is maintained the pressure drop is reduced when the bore or mean diameter of the annulus is increased and the heat transfer rate will increase because of increased surface-squared-to-volume ratio. Increasing the bore results in more accurate control of pressure and less pressure loss. It is, therefore, recommended as the most desirable of these three methods of improving heating cylinder capacity.

A second factor which influences plasticizing capacity is the ability to provide uniform and adequate heating to all interior metal surfaces of the heating chamber. The rate at which the heat flows into the plastic depends upon the temperature difference between the cylinder walls and the plastic (16). This temperature difference is the greatest at the rear of the cylinder, therefore adequate watt density should be provided at this location. It is also essential to supply adequate heat to the upstream end of the torpedo. If a slab of plastic is heated from both sides, it can absorb four times as much heat as when heated from one side only, because the heat absorption is proportional to the square of the surface area. This concept is

Figure 1

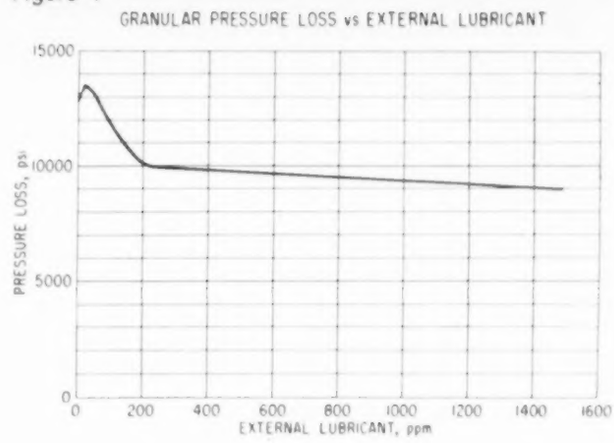


Figure 2

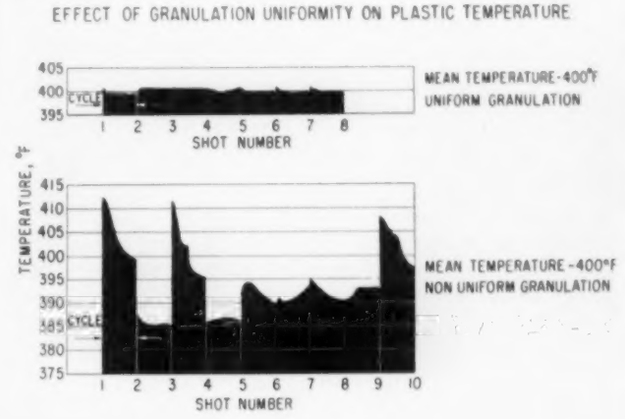
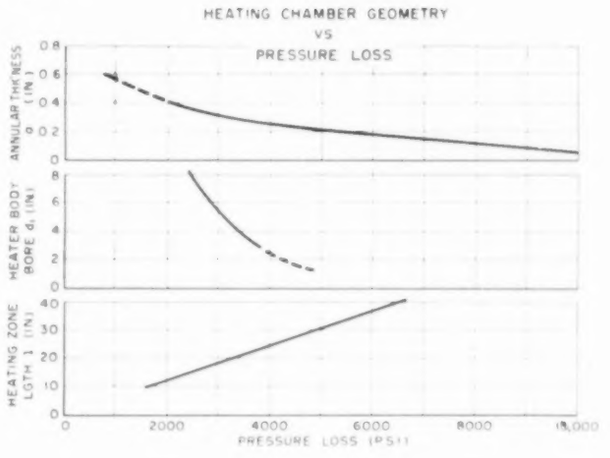


Figure 3



substantiated by data shown in Figure V. A marked increase in plasticizing capacity is obtained when the torpedo heater is turned on.

The insulating characteristics of plastic are a basis for the third factor in heating efficiency considerations. As the plastic becomes heated and fluid it should be moved away from the heat transfer surfaces to make room for cooler plastic to absorb the heat. This has been found to be a good principal of heating cylinder design. It will result in more uniform temperature distribution in the plastic mass. This factor will decrease the pressure loss and improve the accuracy of pressure control (11, 13, 14, 17, 18, 19).

Friction heating is not recommended as a method of increasing the efficiency of the heating cylinder. It has been found the friction loss reduces the available pressure for molding and only thirty percent of the friction heat finds its way into the plastic (13). Friction heat is primarily generated at the wall and since the metal has a higher thermal conductivity than the plastic this heat is absorbed by the metal surfaces (20). Table I illustrates the difference in the thermal properties of polystyrene and steel.

Table I
Thermal Constants

Material	Diffusivity sq ft. hr	Conductivity BTU (sq ft) (hr) (°F per ft)
POLYSTYRENE	0.00504	0.066
STEEL	0.433	26

High watt density is chiefly useful for rapid warm up of the machine from a cold start on Monday morning. It has been found this decreases the uniformity of temperature and pressure control during the rest of the week. Heating needs call for high watt density at the rear end of the cylinder where the maximum amount of heat will be absorbed by the plastic and at the point where the spreader absorbs heat from the cylinder wall. Uniform watt density was provided along the length of one cylinder and the temperature of the cylinder metal ran as much as 150°F. greater than the control temperature at the thermocouple point. Experience and tests indicate generally the watt density along the heater should be balanced to the load of absorption of heat by the plastic, the ambient air and the machine frame.

Plastics in direct contact with heating surfaces quickly attain the temperature of the metal. The thermal stability of a thermoplastic limits the maximum temperature of the heater walls. The improvements in heating cylinder design listed in Table II, which are a summation of the principles previously discussed, have been found to provide good heating at a rapid rate with low wall temperature and minimum pressure loss. These considerations become

Table II
Design Principles for Heating Cylinders

1. No restrictions in cross-sectional area in granular zone
2. As high a cylinder temperature around granules as possible
3. Allow air to escape from between granules
4. High surface area
5. Low volume

   } S^2/V should be high
6. Adequate heat to all surfaces
7. Adequate flow past all surfaces
8. Reduce frictional heat
9. Control of watt density

Figure 4

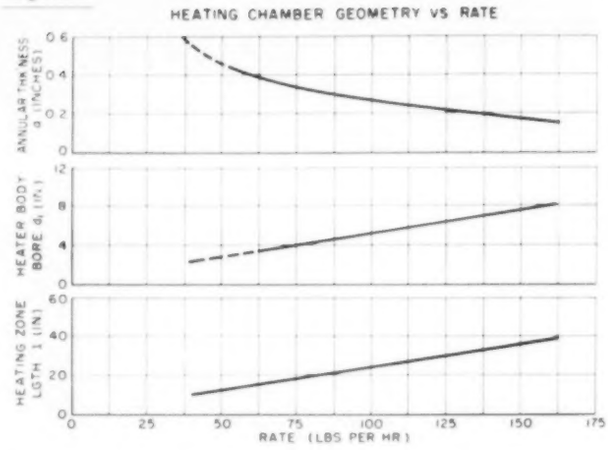


Figure 5

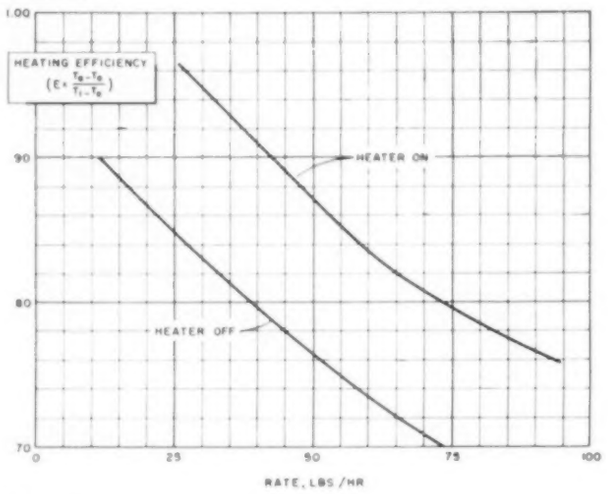
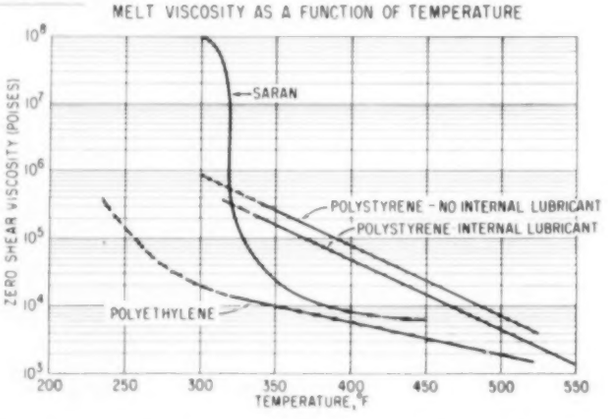


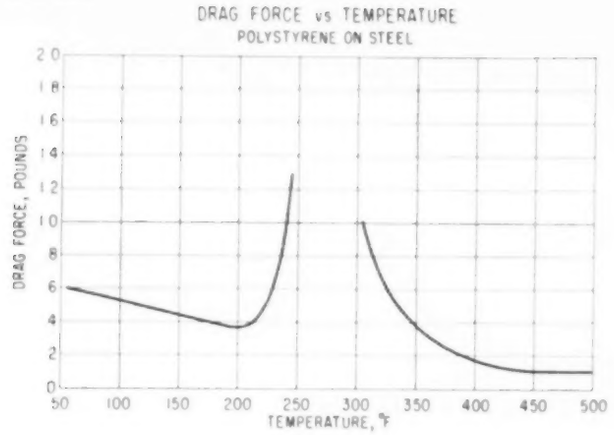
Figure 6



more important when molding some of the new materials being developed which are more heat sensitive than the polymers which we have worked with in the past (21,22).

The resistance of the plastic in the fluid zone is subject to differences according to the viscous behavior of the plastic which is involved. Figure VI is a graph which has been prepared to show the viscosity relationship with temperature for various plastics. The crystalline plastics show a marked drop in viscosity when melting occurs, while polystyrene does not show this sudden drop. Internal lubrication of polystyrene lowers the viscosity which re-

Figure 7



sults in a lower pressure loss in the fluid state. The larger change in viscosity points out the necessity of obtaining uniformly heated plastics. Material which is not uniformly heated has pronounced effects upon the control of pressure in the mold. A sharp drop in viscosity of crystalline materials changes the resistance of the plastic in the fluid zone and this may interfere with pressing the air out of the granular zone and it may cause fluctuation in the pressure in the mold. These differences are likely to require different designs of heating cylinders in the fluid zone.

When the polymer is passing from the solid state to the fluid state it is in a semimolten condition with a very high viscosity. The drag force against the cylinder wall at this time is a factor about which very little is known. Figure VII illustrates the change in drag force of polystyrene on steel with changes in temperature. The position of the curve which is missing represents an area which should be studied (20, 23, 24, 25).

Nozzles

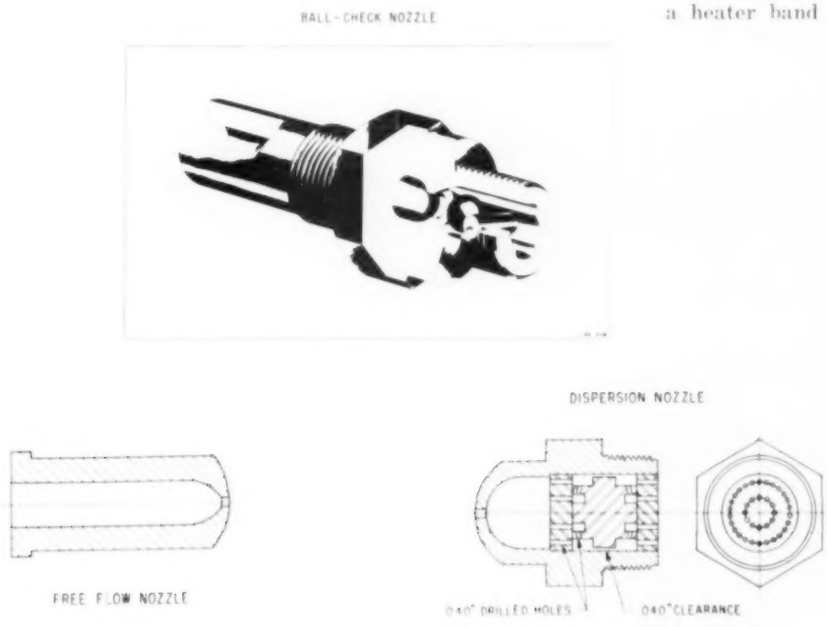
The design of the injection molding machine nozzle is critical from the standpoint of pressure and temperature considerations. It is essential to avoid as much pressure loss as possible in the nozzle and the plastic should be kept at uniform temperature in this region. It is not recommended to try to add heat to the plastic in the nozzle but merely to prevent the plastic from chilling after it has been heated in the cylinder. The long tapered nozzle was described in 1949 as having rather poor properties for pressure conservation, because the decreasing diameter caused a kinetic pressure loss. Later studies indicated the pressure loss became friction heat which was absorbed by the metal of the nozzle and did not add appreciably to the temperature uniformity of the plastic. The free-flow nozzle has found much use in the injection field and it is generally accepted at the present time (Figure VIII). The ball check nozzle, also shown in Figure VIII, was devised as a means of controlling the pressure in the mold cavity. The plastic moves with some restriction in the direction of flow into the mold until the mold is full. When the injection plunger is withdrawn a small amount of plastic is discharged from the mold and pushes the ball check into the seated position. This prevents further discharge from the mold. This type of pressure control depends upon first putting too much plastic in the mold and then letting the excess material escape. This functions, but it is not very accurate as a pressure control means.

Dispersion type nozzles are used in many dry blend coloring applications. The essential features of such nozzles are; to break up the pattern of flow of the plastic and to disperse the color without causing excessive pressure loss. Several designs of dispersion nozzles have been made, one of which is illustrated in Figure VIII (26, 27). The nozzle is not the only region in which good dispersion can be promoted. The flow through the heating cylinder itself has some effect upon dispersion as well. Very little work, if any, has been reported concerning the internal construction of heating cylinders to make them especially suited for dry blend coloring.

The design of the nozzle should include provision for a heater band to control its temperature. This temperature control can be extremely simple and voltage control methods have been found to be very satisfactory. The nozzle heater should be turned on at all times at a low voltage level in order to maintain equilibrium conditions or regulated with a controller which will avoid temperature fluctuations. The nozzle heater serves two purposes, to heat the plastic in the nozzle from a cold start and to maintain uniform temperature by making up for radiation and conduction heat losses.

Sprueless nozzles have been extremely successful in a number of cases. They appear to be well suited for high speed automatic production of thin section parts. Figure IX illustrates examples of this technique as applied to single and multiple cavity molds (28, 29, 30, 31).

Figure 8 Types of Nozzles



Molds

The pressure drop per unit length in the sprue and runner system is dependent upon the temperature of the mold, the viscosity of the material and the cross section area of the passageway. The total pressure drop in the runner system can be reduced by increasing the cross sectional area of the runner, decreasing the length or by raising the temperature of the metal in contact with the plastic. The extreme limit of reducing this pressure loss is to eliminate the runner system entirely by use of sprueless, runnerless or hot runner molds (32, 33, 34).

Precision molding using today's methods requires accurate balancing of the pressure in each cavity of a multiple cavity mold. A common method of balancing the mold is to alter the size of the gate, based upon information obtained from short shots which were caused by reducing the injection pressure. The plastic is a non-Newtonian material. If the pressure is reduced it alters the viscosity of the plastics (24, 25, 35, 36, 37, 38, 39, 40). When the gates are balanced at a reduced injection pressure, they will not be balanced when sufficient injection pressure is used to fill the cavity completely. The proper method is to maintain the injection pressure at a level sufficient to fill the entire cavity and cause short shots by reducing the plunger forward time (41, 42, 43, 44, 45, 46, 47). We believe mold balancing will be less critical in the future when much faster injection speeds are used (48).

Plastic flows into the cavity as illustrated by Figure X. As the plastic contacts the mold surface, it forms a frozen layer. Subsequent material passing through the gate proceeds as a molten core between the two outer frozen layers. It is desirable to maintain the frozen layer as thin as possible until the mold is completely filled. Methods of accomplishing this are: increase the mold surface temperature, increase the plastic temperature, and/or increase the speed with which the mold is filled (10, 49, 50, 51, 52). Laboratory and field tests indicate high speed injection is more efficient in reducing the thickness of the frozen layer than either increasing the mold surface temperature or the plastic temperature (48). Reduction of the frozen layer results in better equalization of pressure throughout the mold cavities and a more stress free part. There is considerable room for additional study and research regarding the mechanics of the formation of the flowing plastic front and frozen layer. They have a dominant influence upon the surface finish and the strength of the molded part and their effect should be studied in more detail (53, 54, 55).

The time at which the moldings can be taken from

Figure IX

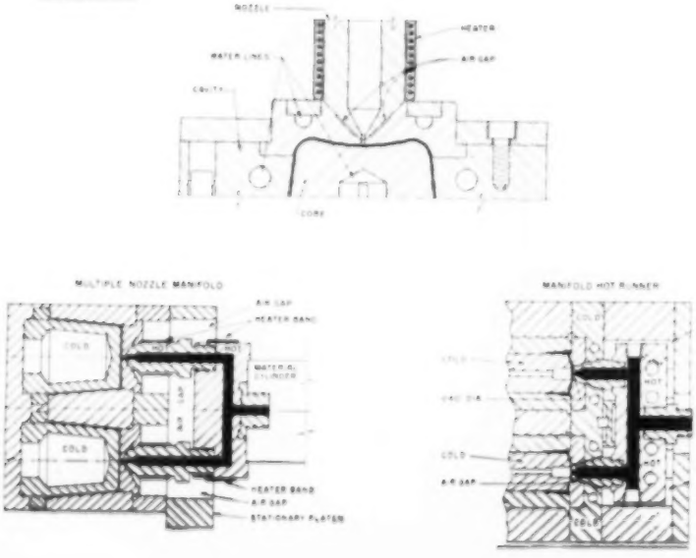
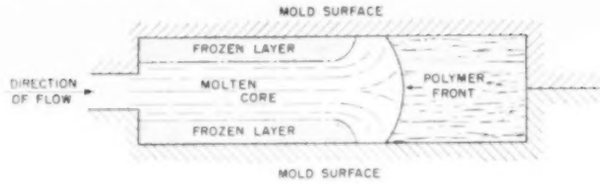


Figure X Plastic Flow in Nozzle.



the mold is dependent upon the heat distortion temperature of the plastic and the amount of molded-in quench stress and orientation strain present (5, 56, 57, 58). Laboratory studies (Figure XI) indicate the cylinder temperature settings have less effect on the cooling curves of the plastic than does the mold temperature. A decrease in mold temperature cools the plastic molding more quickly than does a decrease in cylinder temperature. However, the mold closed time required does not decrease at the same rate because a cooler mold causes more stress and strain to be set up in the part and, thereby, requires the molding to be at a lower average plastic temperature to prevent distortion.

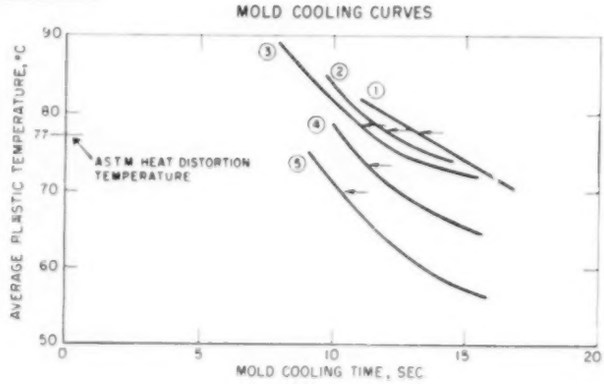
Laboratory studies of viscosity-temperature relationships have been limited to regions approximately 100°F. above the heat distortion temperature. As stated previously there is a need for information regarding the viscosity of the plastic at temperatures considerably below this range. This will provide a more complete picture of what is happening to the plastic as it fills and cools in the mold.

Conclusions

Precision control of plastic pressure during injection molding has been the subject of much detailed study during the past several years and has been the dominant theme of this paper. The majority of the information presented has indicated present and future methods which can be employed to improve the control of the plastic pressure. They are:

1. The control of the pressure within the cavity is directly related to the accuracy with which granules are fed to the heating cylinder.
2. The control and loss of pressure in the heating cylinder is closely tied to the size, shape and treatment of the plastic granules.

Figure XI



	①	②	③	④	⑤
CYLINDER TEMPERATURE	590°F	570°F	550°F	570°F	570°F
MOLD TEMPERATURE	130°F	130°F	130°	110°F	90°F

← Indicates least cooling time to produce acceptable parts

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3. The transmission of pressure through the fluid zone of the heating cylinder depends upon the heat transfer and uniformity of temperature control in this zone.
4. Nozzles, sprues, runners and gates should be designed to distribute the pressure equally to all cavities with minimum loss,
5. Equalization of pressure throughout the cavity can best be achieved by careful attention to the speed of filling, temperature of the mold cavity wall, uniformity of plasticization and the temperature of the plastic.

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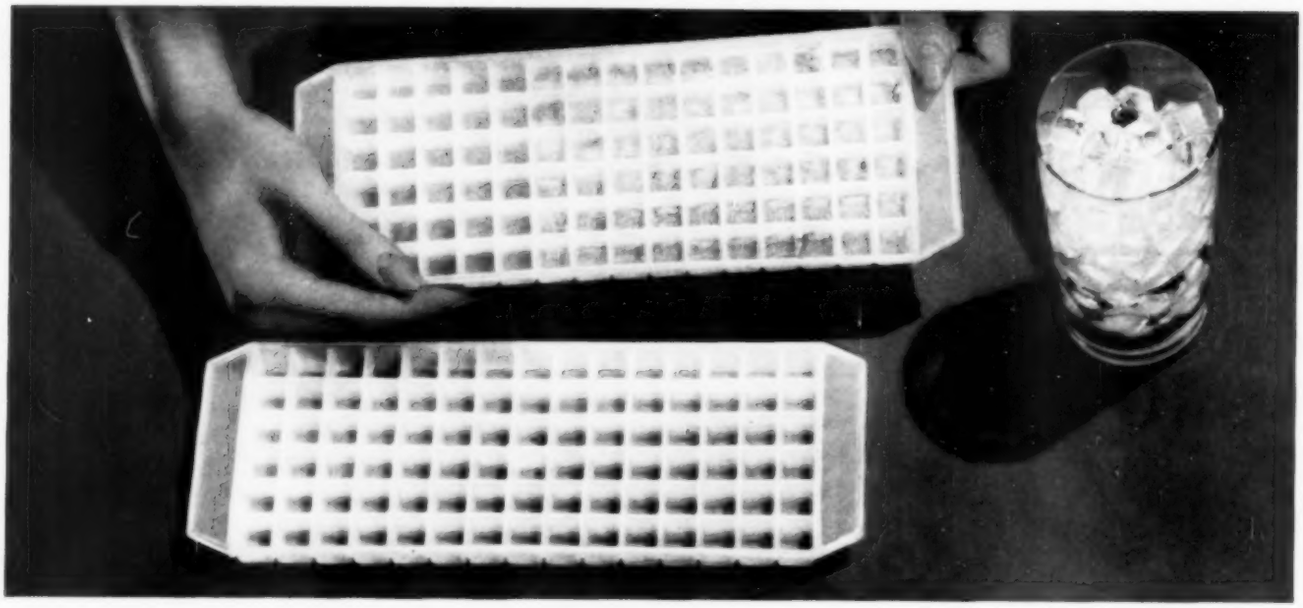

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Action— By Your National Organization

"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

Needed: A New Program

Report to Meeting of National Directors January 17
P. J. Underwood, Executive Secretary

Gentlemen: At the National Council Meeting in Minneapolis last September, I reported to you that two years prior the Society was facing five major problems.

1. Modernization of office systems
2. Increase in membership
3. Better organization of the National Committees
4. Relocation of the National Offices
5. Increase advertising income of the SPE JOURNAL

This was in effect the outline of a program for the Society to accomplish. Last September I reported to you that we had in effect completed that program. We now must have a new program under which to operate. I would urge that our new program be of longer term than our first and considerably more ambitious and challenging. This new program, let's say for the period of 1956 to December 31, 1960, might be considered under two major headings (1) Expanding the services of the Society and (2) Enhancing the stature and prestige of the Society of Plastics Engineers and thereby of its members. The two are very closely related.

1 The first, expanding the services of the Society, will be part of the subject of my annual report to the Meeting of the Membership tomorrow at luncheon.

2 I would like to discuss with you now the second part of my recommendation for the 1956-1960 program, viz. enhancing the stature and prestige of the Society and its members.

There are several methods of accomplishing this.

I. One is of course to increase the size of our membership—for other things being equal the larger the organization the more important a role it can play. We have already made great strides in this direction. Our membership is now very close to the 5000 mark. When we do reach 5000 what should our next goal be? Let's say 10,000 by the end of 1960. But a related question is what should the composition of our 10,000 members be in 1960.

A partial answer to this question is given in the Constitution and By-Laws of the Society in By-Law 1 (quoted)

But we need a definition of these standards.

Engineers Joint Council

The purposes of E J C are

(a) To advance the general welfare of mankind through the available resources and creative ability of the engineering profession.

(b) To promote cooperation among the various branches of the engineering profession.

(c) To advance the science and profession of engineering.

(d) To develop public policies respecting national and international affairs wherein the engineering profession can be helpful through the services of the members of the engineering profession.

The qualifications for membership are

A National Engineering Society may become a constituent society of Engineers Joint Council upon meeting the following qualifications.

(a) The corporate or voting membership shall be confined to individual members.

(b) A majority of individual members shall be either engineering graduates of colleges of recognized standing or shall be licensed or registered by a state board of registration for professional engineers.

(c) Have a total membership of at least 5000 individual members of which the majority must meet the above requirements.

(d) Receive the affirmative vote of not less than two-thirds of the constituent societies of Council.

When we can qualify for membership in E J C our standing among engineering societies will be second to none.

I therefore recommend to our 1956 National President and Council that a determination be made of what the best interests of the Society are in this matter, and that a long range program be launched this year to accomplish them.

II. A second method of improving our standing as a national engineering society is to maintain the highest standards for the technical quality of the information published by the Society both written and spoken.

By-Law I describes this function of the Society.

Recommended to our 1956 officers that they study the need of upgrading some of the technical material we present at our meetings and consider the establishment of a Board of Review to pass on papers before acceptance for our National and Regional Meetings.

This could also concern our local section meetings and if it does, methods might also be studied for ugrading the technical information presented at them.

III. The third method of enhancing our stature as a national engineering society we have not even scratched the surface of.

In our By-Laws it is described as follows: By-Law A-1 Part 1—

> **The objects of the Society shall be accomplished by: Advancing the theory and practice of engineering and the allied arts by: 1. Encouraging engineering research, tests and other original work.**

Under the Professional Activity Committees we have taken a first step in that we now have 22 SPE Representatives in other national engineering societies.

But I recommend to our 1956 council that every effort be made to ensure us that by 1960 our Society will be directly engaged in this type of activity which is one of the most basic reasons for our existence.

Industrial Literature

Europe's Technology

The best articles from European technical and industrial journals, translated and digested, are now available monthly to American industry, John C. Green, Director, Office of Technical Services, U. S. Department of Commerce, announced today.

The Organization for European Economic Cooperation, a multi-government agency set up to stimulate economic growth of member-nations, will distribute its monthly publication "Technical Digests" in the United States. It is designed primarily for those interested in manufacturing and production.

Many of the articles in the periodical, which averages 140 illustrated pages, discuss new products and processes developed by European manufacturers. Designed for clear, concise, easy reading, the magazine contains digests of only the most effective articles gleaned by specialists from over 1,000 European periodicals.

Almost all fields of industrial interest are covered in the "Technical Digests"—ceramics and glass; chemicals; corrosion, protective coatings, finishing processes; electrical engineering and equipment; food and allied products; fuel, power, and lubricants; leather; materials handling; metallurgy, metal working, machine shop; packaging and packing; safety; structural engineering, building; textiles; timber and wood; transport; and many others.

Subscriptions are handled by the O.E.E.C. Mission Publications Office, 2000 P Street, N.W., Washington 6. The rates are $24 a year or $2.50 per single issue.

Adhesives and Coatings

A new 12-page, illustrated catalog listing properties and applications of a wide variety of adhesives, coatings and sealers is now available from Adhesives and Coatings Division, **Minnesota Mining & Mfg. Co.,** 411 Piquette Ave., Detroit 2, Michigan.

Typical applications for adhesives, coatings and sealers in the metal-working, transportation, general manufacturing, electrical manufacturing and building products industries are listed in comprehensive tables in the catalog.

Parallel Glass Fiber

Production of parallel glass fibre reinforced laminates in a pilot plant operation conducted for the Navy Bureau of Ordnance is described in a research report just made available to industry through the Office of Technical Services, U. S. Department of Commerce.

The report describes materials and processes and experiments in the molding and testing of parallel glass fibres into edges and corners, honeycomb sandwich construction, reinforced plastic tubing, and body armor.

This report, PB 111719 **Parallel Glass Reinforcement for Plastic Laminates,** final report, Firestone Tire & Rubber Co. for Bureau of Ordnance, Mar. 1955, 32 pages, may be ordered from OTS, U.S. Department of Commerce, Washington 25, price $1.

Fluorocarbon Bonding

Using a special bonding technique, International Resistance Company, Philadelphia, has succeeded in cladding fluro-carbon plastic with copper. The resulting new laminate, in which no resin adhesive is used, features very low cold flow, zero water absorption, excellent machineability and a water-repellent surface. Also, it is unaffected by acids, alkalies, or common organic solvents.

For further information on copper-clad fluorocarbon plastic, write International Resistance Company, 401 North Broad Street, Philadelphia 8, Pennsylvania—request Bulletin AR-2.

Plastics Uses

The plastics industry is moving into markets that have barely been scratched, says a new booklet issued by **Luria-Cournand, Inc.,** structural plastics engineers and fabricators located in Havre de Grace, Md. Two of the largest opportunities lie in packaging and structural plastics, the company says.

The four-color, 20-page booklet sketches the Luria-Cournand story. It tells how the company started in business prior to World War II as a maker of plastic gun-turret enclosures for military aircraft and grew into a diversified plastics research engineering and fabricating firm. Copies of the brochure may be obtained by writing to Luria-Cournand on company letterhead.

Nylon Molding

A new catalog of nylon molding accessories is offered by Injection Molders Supply Co., 3514 Lee Road, Cleveland 20, Ohio.

Society of Safety Engineers Journal is Published

The Journal of the American Society of Safety Engineers appeared with its first issue in February, 1956. "Through technical articles we will make available to our readers some of the new knowledge in safety . . . discussions of safety philosophy, and present opposing opinions on controversial issues . . ." This quarterly magazine should be of great interest to all plant managers and owners and those concerned with the safety of industrial operations. For more information write to the American Society of Safety Engineers, 425 N. Michigan Ave., Chicago 11, Illinois.

PVC Standards

The Commercial Standard for Rigid Polyvinyl Chloride Sheets, CS201-55, is now available, according to an announcement by the Commodity Standards Division of the U. S. Department of Commerce. Copies may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for ten cents each.

Destaticizers

Completely revised literature shows many new applications and improvements on both products, MERIX ANTI-STATIC #79 and #79-OL. In spite of these many improvements, there have been no cost increases since these products were first marketed ten years ago. Merix Chemical Co., 1021 East 55th St., Chicago 15, Illinois.

Harflex Plasticizer

A new technical bulletin describes a new Harchem plasticizer, HARFLEX 300. HARFLEX 300 is a polymeric plasticizer of outstanding efficiency. The bulletin is available on request to the Harchem Division at 25 Main St., Belleville, N. J. The booklet contains general information regarding this new plasticizer as well as describing its physical properties and characteristics. Also included in the bulletin are basic compounding formulas and typical applications for the use of HARFLEX 300.

THE INJECTION molderscope

By A. R. Morse
President, Injection Molder's Supply Co.

PRELIMINARY: THE POLYLINER

Observers of the always frenzied injection molding scene have commented that never before in the history of our industry has so much money been spent to promote a single idea as has been lavished on the polyliner type heating cylinder. Scarcely a plant or molding area has not had a full scale demonstration. The interest in the polyliner so generated has often reached a fever-white heat. Numerous plants are now in the process of further evaluation of this type of cylinder. Actual results recorded to date have been extremely varied, and no clear cut picture of just what the polyliner will really do on a practical molding level has yet emerged. So many molders, however, are puzzled by the still-confused picture, that even a necessarily incomplete attempt to size up the present trade reactions to the spreaderless type cylinder will be of value.

As a preface—my own personal reaction: all the really basic progress I have seen to date in heating cylinder design has been slow, plodding, painstaking, and quite unspectacular. Once in a while a radical sun-blast has raised the molder's hopes. And once in a while theoretical calculations have raised our hopes that a new idea in cylinder design will pay off. But after the flare of novelty and initial publicity have died away, there have always emerged the few basic cylinder types that have proven successful money-makers for the molder over the years.

Many molders have unfortunately gained the impression that the polyliner, or so-called spreaderless heater represents at last a highly simplified and easy answer to all their heating cylinder problems — that it is an inexpensive kind of cylinder, simple, easy, and cheap to make and maintain, and one which of course will far out-produce any other. Now the life factor will take several years to assess (although I could name a few shops that might qualify to put a new cylinder through an accelerated aging test). And the cost factor is still open, as not enough of this type cylinder have been made to determine what the final price must be on a commercial basis. However, enough opinions on the performance factor have now filtered through so that a few tentative conclusions can be drawn on what the polyliner can possibly do for us.

That there may be a definite place for this style of heater no one denies —and the place at the present writing (March 12th, 1956) seems to be on a single purpose, single capacity job, such as a thin wall nylon bobbin, or a bottle or container cap where the mold runs permanently on a single purpose machine and material. Figured for a certain capacity on a certain machine, the spreaderless type cylinder gives an excellent, and indeed a superior account for itself. But the same cylinder that will run a 1 ounce job on a 12 second cycle does not appear to be able to run a 4 ounce job on a cycle that is comparable to that which can be achieved with other cylinder types that have a larger storage capacity. Attempts to broaden the range of the polyliner are in process. By deepening and or widening the slots, by enlarging the drilled holes, and by providing a spreader or spider to break up the solid center material column it is hoped to increase its molding range. Evidence exists that insufficient attention has been paid to the diameter of the cylinder in relation to its length, and an investigation still remains to be made as to whether a polyliner of greater diameter, in a larger diameter cylinder with higher wattage giving a greater melting area may not be necessary to increase its molding range on any given machine. The tremendous variation in press specifications I will discuss in a minute are probably at the root of this trouble, as the polyliner formulae are practically NOT as universal as they seem to be in theory.

The fact that the polyliner type of cylinder appears to have its performance factor pretty clearly tied in to the cycle is due to the basic limitation of the idea of melting a thin layer of material and then drawing it off quickly. Experiments in cylinder design dating back to the first days of injection molding have always disclosed that such a heater necessarily has a very limited range. What you gain in performance by limiting the section of heated material (and you do gain considerable within a limited area) you tend to sacrifice in overall flexibility and range. And in adapting such a concept to the tremendous variety of machines found in the trade where specifications vary so widely between presses, considerable risk is involved in relying on a single formula.

In contrasting the specifications of just one category of machines for which we have supplied or quoted replacement cylinders — the 4 ounce size, an appalling variety is encountered. The distance between where the plunger stops and the base of the nozzle, for example, ranges from as little as 6" to as much as 26"! The plunger sizes range from 1" to 2⅝" in diameter, with strokes varying from 3" to 12". Cylinder diameters range from 3" to 8", and total overall length including nozzles run from 9" to 39". Injection pressures used vary from as low as 9000 to 30,000. It is virtually impossible to record ram speed **at full injection pressure** because it is so closely tied in with cylinder heats, nozzle sizes, type of material, and mold detail, but while we do not have specific limits, we know that a wide variation does exist, principally for the reason that a job will run nicely on one machine and won't fill on another. Ram speeds at no pressure also range widely, but we have not considered this as a vital specification closely affecting heating cylinder design except as it pertains to maximum overall cycle possible caused by plunger return time and duration of plunger stuffer strokes when used.

Wattages specified range from as low as 3000 to as high as 17,500! Watt densities of bands used range from as low as 28 to as much as 50 watts per square inch. These watt densities seem to bear no relation whatsoever to the square inches of

(Please turn to page 57)

Injection molders, machinery, and material men are invited to contribute their comments on polyliners or on any other topic. Your remarks will be printed verbatim with full credit given to the contributor, or else we can edit them, and make ourselves the channel where your opinions can be expressed with complete anonymity, whichever you wish. So let's get some more opinions—on the polyliner, on press design, on automatic molding, on material problems or what have you, pro or con! Address your letters to 3511 Lee Road, Cleveland 20, Ohio.

NEWS of the industry

Design Contest for Use of Rods and Tubes

Cadillac Plastic and Chemical Co., Detroit announces two concurrent design contests for applications of thermoplastic rods and tubes.

First prize in the open contest is $1,000. Second prizes of $150 are offered in each of the following three categories: consumer product; industrial or technical product; architectural or decorative.

Entries in the open contest are restricted to product designs already in production or in tooling by December 1, 1956.

The parallel contest for students offers top prize of $250 and three second prizes, applying to the same categories, of $75 each. Student designs are eligible whether in sketch or in production or imaginative exercises.

All designs will remain the property of the individuals submitting.

Any usage of cast or extruded rod in any thermoplastic material in application to any phase of consumer or industrial products is eligible for the contests.

Criteria for the awards will be: aptness and interest of the application; problem solving ingenuity, and understanding of the functional possibilities of the thermoplastic material.

The contest judges are: John Arnold, associate professor of mechanical engineering, Massachusetts Institute of Technology; George Beck, industrial design manager, Television Receiver Division, General Electric Co.; William T. Cruse, executive vice president, Society of the Plastics Industry, Inc.; Hiram McCann, editor **Modern Plastics** magazine; Jane Fiske Mitarachi, editor, **Industrial Design** magazine; and Jean Reinecke, Reinecke & Associates, design consultants, Chicago.

Entries, in the form of photographs or sketches, may be submitted by individuals or design teams or by firms or school departments, separately or jointly. Number of entries by any individual, firm or department is unlimited.

For information and entry forms, prospective entrants may write to Ladd Orr, IDI, Contest Advisor, c/o Cadillac Plastic and Chemical Co., 15111 Second, Detroit 3. Information is also available at Cadillac Plastic branches in Chicago, St. Louis, Los Angeles, and San Francisco.

Precision Parts—COLD

A new cryogenic process which has many important advantages in the production of high precision machined plastic parts has been announced by Standard Automation Products. Using conventional Swiss automatic screw machines and other conventional machining equipment, Standard Automation machines many plastics under controlled ultra-low temperature and atmospheric conditions. The types of plastic parts which can be produced using the Cryogenic Process include pinions, arbors, axles, toothed wheels, gears, shaped parts, nuts, screws, and compound parts. The new process is effective for producing large plastic parts as well as miniature and subminiature pieces.

Among the many advantages of the Cryogenic Process are significant improvement in dimensional stability and tolerances obtainable, lowered costs due to reduction in rejects, faster rates of production, more uniform parts, better surface finishes, and elimination of some secondary finishing operations. The new process is most useful in producing parts from plastics which have a high coefficient of thermal expansion. Many plastics which have had only limited application in precision design because of fabrication difficulties can now be economically machined to extremely high standards. For further information write to Standard Automation Products, 1738 Ridgeway Road, Havertown, Penna.

U.S.I. Polyethylene

The Petrothene(R) 300 series of electrical grade polyethylene resins has just been introduced by **U. S. Industrial** Chemicals Co., Division of National Distillers Products Corporation, 99 Park Avenue, New York 16, N. Y. The new series meets a variety of electrical specifications for infantry field wire, line wire covering, TV lead-in wire, high frequency and high voltage insulation and, in general, all wire and cable insulating and jacketing applications.

Shell Epoxy Plant

Shell Chemical Corporation is building a new resin unit at its Houston plant to manufacture market development quantities of new epoxy resins. It will begin producing in early April. The unit will produce new developmental resins and curing agents for customers' experimental use and small commercial production.

Seminar at M.I.T.

"Plastics in Building" will be the subject of a two-week Special Summer Program to be given at the Massachusetts Institute of Technology from July 2 through July 13 during the 1956 Summer Session.

The Program will study plastics and their growing use in buildings, as exemplified in the design and detailing of a small residential structure, according to Professor Ernest H. Huntress, Director of the M.I.T. Summer Session, who announced the program.

The program will first be concerned with creative application of the principles of good design to determine the basic form of the structure. Problems of acoustics, lighting, thermal controls, and space arrangement—all related to the primary function of the structure—will be analyzed and discussed. The site location and its influence on the form will be examined, and the problems of erection, dissembly, and storage will also be considered.

Ace Expands

The addition of 25,000 square feet of space to the Extrusion Department of Ace Plastic Company, extrusion molders and fabricators, 91-60 Van Wyck Expressway, Jamaica 35, N. Y., brings the company's total area to 75,000 square feet.

Ace feels that this additional area now gives them space to service their customers with their present line of various standard plastic rods, tubes and other shapes.

Cyanamid Color

American Cyanamid Company's Pigments Division has announced the addition of Cyan Green Toner 15-3100, a strong, clean phthalocyanine green toner, to its expanding line of durable pigments. Like other Cyanamid phthalocyanines it has high strength and excellent stability to light in exterior finishes.

Chemically, Cyan Green Toner 15-3100 is chlorinated copper phthalocyanine. Physically, it is a finely divided dry powder having a specific gravity of 2.24. It bulks 0.0535 gal./lb. in displacement in composition formulations.

Kellogg Polyolefins

The M. W. Kellogg Company announced today that it has purchased a large piece of property in the Houston (Texas) Ship Channel area as site for a contemplated plant for the production of new types of polyolefin plastics.

Kellogg's parent company, Pullman Incorporated, recently announced that it had signed a license agreement with Phillips Petroleum Company looking toward production of these plastic materials by a special process owned by Phillips.

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

Vinyl Dry Blend Extrusion

Vinyl chloride polymer is a light powdery material. It must be mixed with various plasticizers, fillers and stabilizers, in order to give desired properties. General practice has been to compound this mixture with a banbury and/or millroll and then pelletize it into approximately $\frac{1}{8}$" cubes for subsequent processing. Extrusion of a granulated compound such as this is a relatively simple process, provided ordinary precautions are taken to avoid decomposition.

It was soon realized that the extruder itself was an excellent piece of equipment for compounding and that appreciable savings were possible by utilizing it as such. Development of the dry blend process was a natural consequence. In this process, a dry blend resin (special particle size and shape) that has good plasticizer absorption properties is blended with the plasticizers and fillers. The resulting blend is sandy in appearance and can be extruded directly.

The quality of the finished items will depend, to a certain extent, on the type of resin used, temperature and time relationship of resin and plasticizer additions, and the uniformity of the mixing action. The extrusion operation, however, holds the key to the successful application of the dry blend process.

With proper screw design it is possible to produce almost any item from dry blend that had previously been made from compound. It must be realized that the preparation of vinyl dry blend itself does not involve any operations that are not usually done before conventional compounding. Consequently, it is necessary to perform a certain amount of work on the material in order to achieve complete homogeneity. The amount of work that the screw must do will depend upon the quality of the dry blend and the end-product requirements. The manufacture of clear transparent garden hose from dry blend is common practice.

The most common quality defect in vinyl extrusion that can be attributed to the dry blend or to the extrusion operation is the presence of "fish eyes." Actually, each resin particle of the dry blend should have the same amount of plasticizer as the next and should be uniform throughout. In practice, however, some particles have less plasticizer and may have centers that the plasticizer has not reached. We must depend upon the extruder to work these out to yield a completely clear and smooth product.

Because these hard cores or "fish eyes" are cushioned by the plasticized material surrounding them, the shearing action must be rather vigorous in order to smear them out. Obviously straight mechanical mixing or turbulence would not normally be sufficient to perform this operation.

When dry blend is run on a deep flighted compound screw, it will be noted that in many cases the plastic is not in the form of a melt until the last flight or, in some cases, not until it actually reaches the breaker plate. In screws where the powdered blend is carried well forward in the extruder before forming a melt, porosity in the finished items may develop. This happens when air is entrapped in the plastic melt and then carried out through the die. Thus, if we can develop the melt region at a point further from the die in such cases, we will improve quality. First, the longer distance permits greater mechanical working of the melt to reduce "fish eyes." Second, plasticizing further back will reduce the tendency to entrap air. The following suggestions are useful in increasing the length of the melt region in order to circumvent these problems. There are several ways to increase the amount of working or shearing that a given extruder will do. The simplest method is to increase the back pressure on the screw and subject the resin to a longer dwell time in the extruder. This can be done by the use of additional screens and in most cases will reduce output. The presence of the screens themselves, except to increase back pressure, are of little assistance in reducing "fish eyes," that is, they have no filtering action.

Another method is to use cooling water in the screw. This has the net effect of reducing the flight depth and increasing the shearing action. Because this may cause a temperature rise as a result of higher shearing, it should be carefully observed and controlled. A drop-off in rate may be noticed with this method. Although cooling water and screen packs may not eliminate "fish eyes" in all cases, they are extremely useful production tools.

The preferred method is to alter the screw design. Best results to date have been obtained by using a screw with a so-called "metering section." This is a screw which has the last 3-4 flights of constant geometry. At the same time, it is desirable to make the flight depth in this region as shallow as feasible. There will be a direct relationship between the flight depth and output. The output will be reduced as the flight is made shallower, but the quality will improve. This will be compensated for to some extent by the fact that at the same screw speed dry blend normally extrudes at a higher rate than compound.

Greater screw speed will naturally increase output, in many cases without loss in quality. Stock temperature may increase, and once again, this should be carefully watched. Too high a screw speed may in some cases reduce the time in the extruder to the point where there is insufficient compounding.

The most satisfactory answer to the dry blend extrusion problem is to lengthen the extruder barrel. It is our opinion that the extruder for vinyl dry blend should be a minimum of 16-1 Le D (length of the extruder from front of feed hopper to end of barrel divided by the diameter of the barrel). We prefer a 20-1 Le D screw. With a longer barrel and properly designed screw, increases in inventory time, shearing and output can be accomplished. The cost of modifying equipment — or if purchasing new equipment, the additional cost—is in most cases easily recoverable in the resulting production savings.

To some, the story on longer barrels may seem over-emphasized. There are those who feel that increased output is not always attained. Changes in the length of the extruder normally are made simultaneously with modifications in screw design. Under certain circumstances, it is

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AROUND THE WORLD

UNITED STATES

ELECTRICAL MANUFACTURING

Vol. 56, No. 5, Nov. 1955

Abstracter: Gerald Eisner

POLYVINYL CHLORIDE FOR MOLDED PARTS — Charles W. Bulkley, pp. 106-112

From the Monsanto Plastics Division comes this general discussion of Molded PVC. Those properties which would be of particular interest to the electrical engineer are considered in some detail and molding advantages are described.

Among the features brought out are softness, flexibility, resistance to oil, grease, ozone and moisture, insulating ability and corona resistance.

Vol. 57, No. 1, Jan., 1956

ISOCYANATE-RESIN-COATED GLASS CLOTH INSULATION— Herbert G. Steffens, pp. 114-115

The author describes in this article the important electrical and mechanical properties of isocyanate resin coated glass cloth insulation developed and tested at the Natvar Corp. His claim for this material, which is designed for use in equipment operation between Class B and Class H temperature ratings, is continuous performance at temperatures in the neighborhood of 150°C and superior resistance to crazing.

Tables of properties and performance charts are included.

Vol. 57, No. 2, Feb., 1956

ADHESIVES AS A DESIGN TOOL — Arthur E. Kott, pp. 87-93

Adhesives have been described as "chemical fasteners," and they can thus be designed into a product essentially like any other component. They can help resolve specific design problems, such as space factor or weight reduction, and they can provide production advantages unobtainable with other joining means.

In this article the author reviews the major types of adhesives and relates their properties both to types of materials to be joined and to product applications.

Vol. 57, No. 3, March, 1956

NEW PLASTICS MOLDING MATERIALS—Alex E. Javitz, pp. 90-101

Mr. Javitz, an editor of ELECTRICAL MANUFACTURING, has assembled data from an extremely wide variety of sources to give the reader thumbnail sketches of the lesser known molding plastics for electrical applications. Included in the discussion are the DAP resins, epoxy molding powders, glass filled phenolics, glass silicone compounds, arc resistant phenolics, silicone bearing alloys, flourocarbon elastomers, conductive plastics and boron-based polymers.

Production problems are considered in this article along with the electrical and physical properties.

ARGENTINA

REVISTA DE PLASTICOS

Vol. 3, No. 13, Jan.-Feb., 1956

Abstracter: John B. Ballard

FIVE HUNDRED CO-WORKERS — Editorial

The Argentine Chamber of the Plastics Industry, founded in 1944, had 86 members in 1950. Its membership has now increased to almost 450.

ARGENTINA OFFERS GREAT OPPORTUNITIES FOR THE PETROCHEMICAL INDUSTRY — Bernardo Rikles

Increased production of petrochemical products from Argentine raw materials is believed to be both necessary and economical. For this purpose, development of natural gas resources of northern Argentina is needed.

GERMANY

KUNSTSTOFFE

February, 1956

Abstracter: Anne Schwend

ULTRA-RED SPECTROSCOPY AS DETERMINER OF THE STRUCTURE OF HIGH POLYMERS — W. Bruegel

Until recently spectrometers for investigations in the ultra-red spectrum were not available in Germany. The present article brings a survey on ultra-red spectroscopic analysis of high polymers (polyethylene, polystyrene, polyamides) and natural and synthetic caoutchoucs as published in foreign journals, analysis which gives clues as to composition and physical structure, amorphous and crystalline zones, degree of cross-linking, changes taking place upon vulcanization, sulphurization, oxidation, ultra-violet irradiation, etc.

UREA FORMALDEHYDE CONDENSATES AS BINDERS FOR THE WOODWORKING INDUSTRY — Gustav Hagen

A comparison of kinds of binders used in the U.S.A. and Germany shows that the share of carbamide resins, especially urea formaldehyde condensates, is higher in Germany than in the U.S.A., that the second place is claimed by polymers and copolymers of vinyl compounds and that only the third place is covered by phenolics which rank second in the U.S.A. History, mechanism of condensation, hardeners used, use life, press time and temperature as well as special brands of "Kaurit" binders as produced by Badische Anilinand Sodafabriken for the woodworking industry are discussed.

NEW METHOD FOR MEASURING THE MECHANICAL CHARACTERISTICS OF HIGH POLYMERS — Wilfried Voigt.

Description of the testing machine developed by Lonza-Werke at Weil Rhein for measuring the momentum of thermoplastic films under constant load or constantly increasing speed of load or constant elongation speed at chosen temperatures. The author's opinion: this simple machine overcomes objections hitherto existing as to inadequacy of tensile testing of high polymer films as preliminarily standardized in DIN 53371.

10TH INTERNATIONAL AUTUMNAL CONVENTION OF THE SWEDISH PLASTICS SOCIETY, NOVEMBER 16 TO 18, 1955

A brief resumé of addresses held

at this successful meeting with 56 speakers from various European countries and overseas, addresses which in part have already or will be reprinted in Kunststoffe shortly.

A SIMPLE METHOD TO DISTINGUISH COMMERCIAL POLYAMIDES — F. Stuehlen and H. Horn

The different reactions of commercial polyamides when hydrolyzed with 6n-hydrochloric acid: their rate of dissolution, appearance while hot, after cooling and several hours later, the melting point of crystals separated (if any) and their melting point when mixed with sebacic acid, adipic acid, etc. make it possible to determine the acid components of commercial polyamides without paper-chromatographic analysis. Since two different types of German-made polyamides showed the same characteristics upon hydrolysis, their hot solutions differed very much when brought into 80% ethyl alcohol and cooled down again. Polyurethanes may be distinguished from polyamides by the odor of their combustion gases. Polyurethane gases have a stinging and suffocating odor, polyamides smell like burnt horn, a distasteful but not suffocating odor.

THE EFFECT OF TOP COATINGS ON PVC ARTIFICIAL LEATHER WITH REGARD TO PLASTICIZER MIGRATION — H. E. Frey

A modified form of the "rub-off" test was used for investigating the effect of top coatings on plasticizer migration. In addition, the effect of different coatings on the evaporation and migration of plasticizers into vulcanized natural caoutchouc was checked. Two vinylchloride copolymers of different molecular weight, polymethylmethacrylate, polyethylmethacrylate, polyester isocyanate, Nylon 81 and two resin mixtures with methacrylates served as top films. Only polymethylmethacrylate and Nylon have proven to guarantee a protective top film worth consideration for practical purposes. These tests were conducted by the Research Division, Textileather Div. of General Tire & Rubber Co., Toledo, Ohio.

DESIGN OF INJECTION MOLDS — Hans Gastrow

Description of molds with positive ejector pullback, for parts with external threads placed in screw-off rings and automatic tang break-off as well as for undercut parts with oblique ejector pins and automatic tang break-off device.

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GREAT BRITAIN

BRITISH PLASTICS

Volume 28, No. 12, Dec., 1955

Abstracter: E. A. Mol

THE DEVELOPMENT OF RIGID VINYL SHEET PRODUCTION— By F. B. Makin, Pages 500-504 incl.

The manufacture of rigid vinyl sheet demands, besides high quality calenders, vinyl compounds of excellent stability, high clarity, high softening point, and good batch to batch consistency. BX Plastics, Ltd., manufacturers of Cobex, use a vinyl chloride—vinylidene chloride co-polymer (4% vinylidene chloride) as the resin basis, the other two components are a stabilizer—lubricant and color. The stabilizer system depends on the properties required in the end product. For an opaque white sheet for instance one could use five parts of white lead and two parts of lead stearate per 100 parts of resin. For transparent sheets a cadmium stearate could be used, but also organo-tin compounds are widely applied. A recent development is the use of Epoxides as Epikote 834. Colors must be lightfast, heat stable, non blooming and non staining. A wide variety of pigments is available, sometimes azo and vat dyes are used.

The ingredients are premixed cold and then fluxed and sheeting mills, roll temperatures 140°C front, 130°C back. The material leaves the fluxing mill in a hot rubbery state and is transferred to a hot storage mill for feeding to the calender. The calender in this case is an inverted L-type 4-bowl calender. The most common gauges are 8 - 10.5 and 21 mils, the three standard widths are 36.5, 49 and 56". The article describes the methods used for surface finishing. Two main methods are used, to wit, a surfacing press and a continuously operating surfacing embossing machine. The sheets normally are finished either P/P, P/M, M/M meaning of course polished on both sides and the remaining possibility.

PLASTICS IN HIGH-SPEED AIRCRAFT—By M. G. Church, Pages 495, 496, & 518 incl.

In high speed aircraft erosion is the big problem. For instance, at 500 miles per hour the erosion in rain is so rapid that in a matter of minutes a conventional glass reinforced polyester laminate is eroded to a state of complete uselessness. There is evidence showing that the rate of erosion is proportional to the 7th or 8th power of the speed. Consequently the number of materials giving sufficient protection is very small. In the U.K. and U.S.A. only a neoprene-rubber type coating is permitted, very closely controlled by specification. Even there the best results obtained indicate only a life up to 3 hours in rain. The work done on the subject indicates that void free laminates are a must for best erosion resistance. The temperatures in the boundary layers in flight, even at an atmospheric temperature of –56.5°C. are surprisingly high; of the order of 500 to 530°C. The plastic therefore also must be heat resistant. Right now unplasticized polymethyl methacrylate is reaching its limits of application, it does not permit the speeds for which the newer aircraft are being developed. Even the silicone resins do not offer a complete solution, laminates on this basis are inferior at ordinary temperatures in mechanical strength. The author discusses the possibility of developing completely new partly organic or inorganic polymers as for instance polymeric phosphonitriles.

P.V.A. WOODWORKING GLUES— By J. A. Mills, Pages 497-499 incl.

Discussion of the manufacture and use of plasticized polyvinyl acetate emulsions as glues in veneering. P.V.A. glues are fast setting, colorless when dry and have high dry strength. They should not be used for exterior conditions because moisture adversely influences their strength. The application of P.V.A. in veneering is limited because of the danger of solvent swelling of the glue lines through the sometimes paper thin veneers when treated with finishing lacquers. The main advantage of P.V.A. glues is their fast development of strength resulting in shorter production cycles and quick turnover of equipment.

CONSISTENCY IN GLASS-REINFORCED MOLDINGS—By J. Rees, Pages 480-483 incl.

The applications of glass reinforced moldings are limited because of the difficulties met in obtaining constant results. The aircraft industry prefers the continuous type of reinforcement which limits the actual production methods to hand lay-up or contact lay-up. The inconsistency is caused by air voids, moisture and the degree of resin-to-glass adhesion as influenced by the various sizes and surface treatments. Bristol Aeroplane Co. has developed a new method to produce void free laminates. They call it resin injection molding. The catalized resins are injected into closed matched molds loaded with a predetermined weight of continuous woven glass reinforcements. In the development of this method, the process was studied with the aid of acrylic molds so that the complete cycle was under continuous observation. The article describes briefly how production molds are built starting with a male master cor-

responding to the inside surface of the part to be molded. An example of components produced is: fan blades for the Bristol helicopter.

BRITISH PLASTICS

Vol. 29, No. 1, Jan., 1956

CURRENT DEVELOPMENTS IN FOAMED POLYURETHANES—Pages 5-9, 39

The development of Foamed Polyurethanes in the U.K. is described, which is mostly based on the Bayer German techniques and recipes. All the raw materials are imported, although I.C.I. is developing polyester/di-isocyanates of its own. The best known British products are Foamoprene and Flexalkyd. The latter product is primarily intended for foaming **in situ**. A general summary of the main properties of Foamoprene are given. The material can be safely subjected to dry heat up to 120°C. but when wet, the safe maximum temperature is only 80°C. The resistance against acids is good, but a 10% solution of caustic soda will disintegrate it in one day. In the application of the polyurethane cones the U.K. lags behind U.S.A. and Germany. Main applications are upholstery, packaging, toys, mats, medical, and architecture.

COPPER-CLAD PHENOLIC PAPER LAMINATES FOR PRINTED CIRCUITS—Pages 14-17

The printed circuits have several advantages over the classical wiring. No manual wiring has to be done, no soldering and there is less possibility for mistakes. In some applications a 300% output increase can be realized. The Phenolic Paper base to which the copper is laminated must have good electrical properties even when wet and it must be able to withstand the heat of dip soldering. The laminate is between .02 and .5" thick, the copper cladding is usually .0015" thick. The copper foil used is usually of the electrolytically deposited type. It has a good surface finish and consistency of electric properties. Rolled foil can be used but is too narrow for general application. For bonding the copper foil to the laminate, special adhesives have been developed. The circuit is printed on the copper with acid resistant ink by the silk-screen method, the copper that has not been covered is then dissolved in nitric acid. This takes about 6 minutes. Next steps are: washing in water, neutralizing in diluted ammonia, washing and drying. Before mounting and soldering the acid resistant ink is removed with trichlorethylene.

EXTRUSION OF ACRYLIC TUBE—Pages 20 & 21

Although acrylic tubes can be made by wrapping and casting, the extrusion method is to be preferred when long lengths and no seams are wanted. In the operation described the acrylic used is Diakon LA. The machine used is the twin screw Windsor R.C. 65, the same screws as common for rigid pvc are used. The air pressure inside the extruded tubes is around 2" of water, this pressure has to be closely controlled. The process also uses a lubricated sizing die. To obtain pore free extrudates the acrylic molding powder must be absolutely dry, unless very slow extrusion speeds can be tolerated.

GLASS/POLYESTER TUBS FOR ELEPHANTS—Page 26

Although not very important from a technical point of view, this application is a nice illustration of the strength of glass polyester laminates. The top of the tub is capable of supporting the load of an elephant upon a circle of 10" in diameter, the average diameter of an elephant's foot. Furthermore, that top should not sag more than 1/8" under the weight of the elephant because that wise animal refuses to balance on it if it deflects more than that amount. The requirements are met by building eight layers of 2 ounce glass mat into a thickness of ½", plus one layer of surfacing mat.

BLOW EXTRUSION OF VINYL FILM—Page 30

Short description of the technique used by Greenwich Plastics, Ltd. The chief difficulty to be overcome in extruding vinyl film is of course the thermal instability, very close temperature control is required. The polymer used is straight pvc. of high molecular weight, for general purposes 20 to 25% of dioctyl phthalate is added. The compound is mixed in a Buss Ko-Kneader and then the product is granulated on a Masson cutter. The film is blow-extruded in thicknesses between .001" and .0025" in widths up to 72".

BRITISH PLASTICS

Vol. 29, No. 2, Feb., 1956

GROWING FIELD OF USE FOR P.T.F.E.—Pages 42-45 & 74

P.T.F.E. (tetrafluoroethylene) is made in England by I.C.I. and in Italy by Montecatini. Related polymers like polymonochloro-trifluoro-ethylene are made by Farbwerke Hoechst, in Germany, under the name Hostaflon. It is not made by I.C.I. The main properties of P.T.F.E. are, of course, well known in U.S.A. where Teflon has been on the market for some time. The molding of P.T.F.E. is discussed and follows the same principles as applied here. The material is preformed cold at pressures of 2000 to 3000 lbs. per square inch and sintered at 360°C for say 90 minutes. Extrusion is slow and tricky. Heat transfer is the main handicap. Long dies that act partially as sintering chambers must be used. In designing molds and dies it must be remembered that P.T.F.E. has an appreciable shrinkage and elastic memory. The author also discusses briefly the availability of dispersions for coatings and ends with a short summary of applications as in packing, bearings and electrical insulation.

PART I—MODERN METHODS OF MOLD MAKING—Pages 56-60

Next to the classical methods for mold making, three main developments are worth discussion; they are, Hobbing, Electro-forming, and Spart-erosion. Of these three, hobbing is the most important to obtain cavities. Hobbing is performed cold, the hobbing machine forces a hardened hob into the solid die blank. Hobbing speeds are, of course, low. Most operations take at least 3 to 4 minutes, but sometimes 30 minutes are necessary. The dies are made of special steels to suit this particular cold working method. A commonly used steel contains 1.25% nickel, .5% chromium and .09% carbon. For deep and narrow cavities softer steel and say .07% carbon is preferred. The hobbs themselves are made of carbon chromium steel having a hardness of 60 to 61 Rockwell C.

The electro-forming method is mostly used where a wealth of intricate detail is required. The process consists of depositing a layer of hard nickel onto a master of the required shape and backing up the nickel shell with an adequate thickness of copper to permit the mold to be machined and fitted in a bolster. To do this the surface of the master must be made conductive. The most satisfactory method is found to be the deposition of silver by chemical means. The spark erosion has as its specific feature that it can be preformed after the die has been hardened. Although in theory the spark gap may be filled with air, it has been found that a liquid dielectric is advantageous, both for its cooling effect and for its general electrical properties. The electrode can be of any soft metal, brass is widely used because it is easily machined.

H. R. Husted Joins Guy P. Harvey

The Guy P. Harvey and Son Corp. takes pleasure in announcing that Mr. H. R. Husted has been appointed our representative in Michigan.

His address is: Mr. H. R. Husted, Box 684, Brooklyn, Michigan, Phone 219J4. Mr. Husted is a member of the Detroit Section and former member of the board.

SECTION NEWS

Edited by

Stanley Bindman

Jamison Plastic Corp.
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Newark

Extrusion and Automatic Forming

Robert Bostwick

The monthly meeting of the Newark Section was held on March 14 with approximately 120 members and guests attending. Plans for a repeat performance of last year's successful field day at Mazdabrook were discussed. The date of the picnic this year has been set for June 7.

The first item on the evening program was a General Electric film on extrusion and automatic vacuum forming. The film was introduced by Mr. D. A. Davis of the GE Major Appliance Division at Louisville, Ky., and showed production of refrigerator door liners. Mr. Davis recounted how a decision was made by GE three years ago to manufacture its own plastics components at Appliance Park, particularly refrigerator door liners. An engineering study of the vacuum forming technique indicated that the normal machine leaves the operator with too much idle time. Automation techniques were applied and a multiple machine devised to make 100 liners per hour with a minimum amount of idle operator time.

The film demonstrated quite clearly the operation of such a machine in actual production. The process starts with the extrusion of a .093 inch thick sheet of high impact polystyrene. The extruded sheet is immediately laminated with a one mil sheet of clear polystyrene from a roll of film. The laminated sheet is automatically cut by a traveling shear and automatically stacked for delivery to the automatic vacuum forming machines. The vacuum forming machines are four-position machines. First position is the loading point where the operator inserts a flat sheet after first removing a formed sheet from the fixture. Second position is within the machine where the sheet is heated. Third position is exposed and is where the vacuum forming takes place. The mold itself and the actual drawing of the sheet were very interestingly shown in the film. Fourth position is cooling. In the interval between loadings, the operator cuts off the edges of the formed sheet in an automatic stamping machine.

The second item on the program was a report of an SPI committee on standards for injection molding machines. This was originally scheduled to be presented by Mr. A. J. deMatteo of Watson-Stillman. Unfortunately Mr. deMatteo was ill and Mr. F. G. Deagle of Reed-Prentice substituted at the last moment. The Newark Section is much indebted to Mr. Deagle for his willingness and able presentation. Mr. Deagle explained the origin of the SPI committee as composed of molding machine manufacturers interested in standardization. Proposed standards have been prepared to achieve interchangeability of molds from one machine to another and to measure machine performance.

Mold standards include recommended stripper patterns for knockout pins and a recommended grid pattern for bolting. The latter pattern was designed to accommodate both T-slots and tapped holes. Also shown were nozzle radius and locating ring standards. Performance standards include clamping capacity, shot capacity and plasticizing capacity. The latter two are measured with the use of a standard Dow polystyrene, a Dow thermocouple nozzle and a standard stock temperature of 420 ° 10 F.

Mr. Deagle explained that acceptance and practical use of these standards is still in the future. He urged all interested parties to aid in this standardization program by expressing points of agreement and disagreement.

Door prizes were donated by Orangeburg Mfg. Co., Gering Products and Plastic Horizons.

The Section Board of Directors has voted to donate a year's subscription to the S.P.E. Journal and copies of the 1955 and 1956 Technical Conference Reprints to the libraries of the following colleges in this area: Newark College of Engineering, Stevens Institute, Princeton, Seton Hall, Fairleigh-Dickinson, and Rutgers.

Philadelphia

Hydraulic System Maintenance

C. H. Jepson

The March meeting of the Philadelphia Sections of SPE and SPI was organized as a panel discussion on "Hydraulic System Maintenance." The meeting was the largest of the current season, and brought forth many questions from members and visitors. The discussion was held in three parts, with an equipment supplier, an oil company, and a plastics molder, discussing various parts of the problem of effective maintenance of hydraulic systems.

The first speaker was Mr. G. C. Bonnell, Assistant Service Manager of Vickers, Inc. Mr. Bonnell discussed some of the changes that have taken place in hydraulic units, showing how these have made care and repair easier. In addition, he indicated several specific problems, such as oil foaming, that seemed to occur frequently in the field. Air in the system, frequently a result of foaming, was pin pointed as a major source of trouble in hydraulic systems.

Mr. R. Q. Sharpe, Senior Engineering Representative of Socony Mobil Oil Co., Inc., outlined desirable characteristics of hydraulic fluids for plastics molding presses, and showed how one could get into difficulty by choice of the wrong oil. One major item of interest was the finding that standard oxidation tests frequently do not correlate with actual service tests. Mr. Sharpe discussed three new types of fire resistant fluids that are now being made, or are in a late stage of development. The uses for these new oils, as well as the problems encountered with them, were discussed in detail.

Completing the panel discussion, and bringing into it the viewpoint of the user of hydraulic systems, was Mr. Gene Quear, Supervisor of Plastics Engineering Section, Delco Remy Division, General Motors Products. Mr. Quear's comments included a number of illustrations of cases where poor maintenance had caused large economic losses. He put major emphasis on the keeping of adequate records, records that would show the basic cause of every bit of lost time in the manufacturing operation. With such records it is much easier to see where maintenance is faulty, and to focus immediate attention on the true source of the problem.

New members of the Philadelphia Section of SPE are: Harry W. Cyphers, Daniel G. Welsh, J. E. Alexander, Earl B. Wismer, Kenneth D. Walker, Jr., Daniel B. McAfee, James B. Sheffer, Jr., Robert T. Burns, William M. Punnett, Alfred J. Green, Robert Russo, William L. Moore.

Connecticut

Handling and Uses of Acrylics are Discussed

David Mersey

The Connecticut Section met on the second Friday of March at Bridgeport. Robert Gardner and Thomas Hamilton presented the program on Plexiglas for Rohm and Haas Co. In going into the history of this material, Mr. Gardner showed that it was first marketed in 1938, and because of its clarity and fire resistance found a ready application in the auto industry. Dodge was one of the first users, as a replacement for nitrate sheeting. The first molding materials marketed were formulations, A, F, and R. The distortion and melting temperatures of these materials were much lower than the present formulations, V, VM, and VS. Clarity is also improved in the newer formulations.

Aside from sheet, Plexiglas now comes in pellet or granular forms, in either fiber drums or one thousand pound pallets. In order to inhibit moisture absorption, shipping containers are lined with polyethylene.

Mr. Gardner discussed drying methods and temperatures, annealing techniques and temperatures, then went on and described some of the decorating methods used in treating Plexiglas. He was very well supplied with samples showing plating, laquering, casting, embedding, forming, and bonding.

It would appear that Plexiglas has characteristics that can be found in few, if any, other materials. A quick summary shows that it has: extreme clarity . . . lenses; brilliance . . . medallions, ornaments, etc.; weather resistance . . . signs and sign letters; dimensional stability . . . drawing instruments; impact resistance . . . Tail lamp lenses; chemical resistance . . . pen barrels; color . . . complete range; odorless; compatible with human tissue . . . teeth and eyes; electrical resistance . . . cable clamps.

Mr. Gardner then described the new method of attaching finished Plexiglas parts with a mastic compound. This, in many ways is superior to doing the same operation with any other method, whether it be with screws, rivets, lugs, or adhesives. The mastic is made of a synthetic resin. The combination of this mastic compound with Plexiglas molded parts places this material in a position where it now competes favorably with die-cast metal, especially in the automobile industry.

This presentation was very timely, coming right after two substantial price reductions in this material. Pricewise, it now competes with some of the cellulosics. In any event, these reductions will open many new fields of application.

Rhode Island and S. E. Massachusetts

Use of Good Design is Advantage in Vacuum Forming

Glenn A. Tanner

The attendance at the March meeting of the Rhode Island and South Eastern Massachusetts Section was held down due to the double-header blizzard which welcomed Spring to the area. Only 20 members braved the still icy and snow covered streets, but their efforts were rewarded in a fine talk by Mr. E. B. Stratton of Auto Vac Corp. in Bridgeport, Conn.

Mr. Stratton pointed out many of the new ideas which have been brought out by this fast growing segment of the plastic industry. Although a few years back any such speech would have commenced with an historical background showing how this industry actually has its roots in the 19th century, it has now grown to such a point where it can stand on its own two feet to be judged on its own current merit.

These merits are usually based on the artistic intricacy of design. This is much more true in this work than in any other section of the plastic industry.

A new firm starting up has lots of problems, but if they can come up with a new and very clever design, they can be successful in short order. Of course, there is always the chance that the opposite will take place. Of the new firms that have been successful, each one seems to have an abundance of new, sometimes radical and often secretive ideas. Because these ideas can be copied and put on the market within a matter of weeks, the security in these plants is very tightly held. Because of the variety of products which are produced and the variety of effects which are attained, the procedures and techniques of the industry are often controversial. Mr. Stratton said that for these reasons the industry is rife with variables and rife with problems.

One of the great advantages of this vacuum forming procedure is the fact that samples may be produced at little or no tooling expense. Once samples have been issued and approved, it is often possible to have full production underway two weeks later. This is in quite a contrast to the injection molding and compression molding industry.

If all steps in the process have been thought out correctly, it is possible to have even this first production with less than ½ of 1% rejects. However, if bad techniques are employed there can be up to 10% rejects. These factors all cloud the profit picture of the industry and like any other, both successful and unsuccessful ventures can be found within it.

Another contrast to the usual thoughts in the plastic industry, is the fact that since the success of the product is so dependent upon the technique and the operation of the equipment, the ultimate authority that must be referred to for assistance in vacuum forming appears to be the equipment manufacturer rather than the material supplier. Of course, the assistance of the material supplier cannot be discounted and they have done much to help advance this industry, but the equipment manufacturer is constantly testing, producing samples for customers and therefore working much closer with these prospective new ventures.

This process was somewhat limited in its application up until about 3 years ago, where it was almost entirely restricted to the production of relief maps, displays, and toys. Now, however, vacuum forming pieces can be found in 40 different industries. Mr. Stratton showed us samples of wall decorations, appliance field, lighting masks, Halloween masks, packaging blisters, displays, seedling pony size containers, florist pots, and skin type packages of all sorts. Some of the most astounding, perhaps, were the new clear plastic containers made of 7½ mil acetate, which allow the grocer to obtain 4 cents more per pound for the same tomatoes that would be otherwise packaged. In the hardware field, it is found that a 3 cent plastic box helps considerably to sell a 15 cent item. Mr. Stratton explained the method used and these processes, and others whose case history were extremely informative.

His speech was followed by a very active question and answer session that was enjoyed by everyone.

A very attractive display was furnished for the meeting by Monowatt Division of General Electric Co. through the efforts of Mr. Alan Barker. Door prize of the evening was won by Mr. William Augat, Jr., and was furnished by the Ralph B. Symons Associates, Inc. of Tiverton, R. I.

Chicago

Mylar Film Uses

Lloyd E. Parks

The Executive Committee of the National Council met with us and the following people were present: J. L. Formo, President; Jules Lindau, Vice President; P. W. Simmons, Secretary; Wayne Pribble, National Treasurer; Don Hoffman, Professional Activity; Otto Wulfer, Chrm., 1957 Conference Committee; James Davidson, Natl. Dir. Kentuckiana Section; R. K. Gossett, Natl. Dir. Chicago Section.

Mr. Charles D. Cummings, Technical Representative of the E. I. DuPont de Nemours & Company, presented a sound film illustrating the outstanding properties of polyester film and showing the material in use. His story follows:

Remarks on "Mylar" Polyester Film "What's It To You"

"Take a plastic with a high melting point, form it into the strongest film known, give it resistance to a wide range of chemicals, and prove its electrical insulating properties and you have one of the most exciting products to come along in years . . . du Pont "Mylar" polyester film.

"Mylar" has high tensile strength, high tear resistance and high impact strength. In fact, it is the strongest of all plastic films. "Mylar" has an operating temperature range from -80° to 300°F. Chemically, "Mylar" is not affected by most solvents, alkalies, acids and reagents. Electrically, "Mylar" has high insulation resistance, lower power factor, and high volume and surface resistivity.

"The important thing to remember about "Mylar" is that it has not just one of these properties but possesses a balance of them all. How is this done? Is there some special ingredient or coating on "Mylar" which time might wear out or lose its effectiveness? Actually, "Mylar's" properties are right in its molecules. Its two basic raw materials are terephthalic acid and ethylene glycol. In the manufacture of "Mylar," it is important to note that no plasticizer is used. "Mylar's" toughness allows it to be manufactured from semi-rigid gauges down to .00025", or $\frac{1}{4}$ the thickness of cellophane on a pack of cigarettes.

"Because of "Mylar's" unusual properties, we are able to produce effects which are both beautiful as well as practical. Combining "Mylar's" physical and chemical properties, the film is being used widely as a surfacing material in combination with wood, metal, paper, leather, plastics and a wide variety of other materials. These laminations produce washable wall coverings, drapes and upholstery material with exciting highlights through metallic yarns. Many new and attractive laminations are being utilized in the automotive trade, furniture manufacturers, and in other applications in the home and industry.

"Mylar" is being widely used as a base film for magnetic recording tapes and pressure sensitive tapes. Here, the superior strength of the film will permit the use of a thinner base film which results in more recording placed on each reel, moisture and temperature insensitivity, and dimensional stability. Pressure sensitive tapes are used for bundling, splicing, and masking. Here the polyester film provides great strength and good chemical and abrasion resistance.

"One of the things that has brought "Mylar" such wide public attention is its affinity for metalization. The metalized laminations are going into places where abrasion resistance and cleanability is of importance. Panel inserts for automotive and airplane interiors, displays and signs, radio and television sets, home appliances, clocks, ladies shoes and hand bags, wallets, luggage, and even place mats are made more beautifully durable with these metallic film laminations. As mentioned previously, "Mylar" has made it possible to produce a metallic yarn which has strength so that it can be knitted, has heat resistance so that it can be dyed at the boil, and will not tarnish when used in washable fabrics.

"From all present indications, there will be no limit to the possibilities surrounding this fabulous polyester film. We have touched on some of its applications in products for the home, industry, transportation and distribution. "Mylar" is improving products in all of these fields. We think it can help you in some product you are making today or some product you are contemplating in the future."

Membership Competition Chart

Section	Membership Chairman	Members July	Members Oct.	Quota To Go	Quota Met
Baltimore-Washington	B. E. Franklin	84	91	17	124%
Buffalo	R. A. Baumgartner	76	77	15	46%
Central Indiana	John E. Anderson	46	54	13	193%
Central Ohio	Wm. Croll	50	50	15	40%
Chicago	Earl Wilson	354	373	71	55%
Cleveland-Akron	Carl W. Virgin	219	233	45	111%
Connecticut	Lewis Pentland	102	110	21	43%
Detroit		201	216	40	90%
Eastern New England	Joseph P. Clancy	163	176	35	74%
Golden Gate	Robert S. Ward Leonard Faber	42	46	10	80%
Kansas City	Robert Thomson	52	52	15	120%
Kentuckiana	A. Roche	4	24		
Miami Valley	Fred P. Williams	99	105	21	61%
Milwaukee	Martin Bretl	42	43	10	200%
Newark	R. K. Louis	428	442	85	62%
New York	Edward L. Larkin	443	474	92	78%
Northern Indiana	John L. Haugsrud	23	23	10	210%
Northwest Pennsylvania	D. A. Leet	86	88	20	25%
Ontario	N. D. Hall	122	122	21	110%
Pacific Northwest	Don Le Gassey	32	33	10	10%
Philadelphia	Fred Hillsley	230	249	47	102%
Pioneer Valley	Frank Z. Bailey		4		
Pittsburgh	Charles Snyder	61	61	15	53%
Quebec	J. Chapman	107	109	22	59%
Rhode Island & S. E. Mass.	Sydney Lohman	83	87	20	70%
Rochester	Albert F. Patterson	73	76	15	100%
St. Louis	Chris. Kacalieff	43	43	10	60%
Southeastern Ohio		138	150	28	136%
Southern California	Lawrence B. Green	60	62	15	60%
Southern Section	William B. Erb	41	41	10	90%
South Texas	Carl Eckenrod	66	70	15	60%
Toledo	Gunther Griefelt	69	75	15	147%
Upper Midwest	Orville Hultgren	202	202	40	63%
Western New England	Walter G. Clark	58	69		
Non Section					
TOTALS		3951	4182	830	82%

S. E. Ohio

China History

Arthur Randell

The February meeting of the Southeastern Ohio section was held at Bakers Coffee Shop on Route 40, February 21, with dinner at 7:30 p.m.

Since Engineer's week was celebrated all over the nation, we were invited to a joint meeting, including ladies, with the Professional Engineers from Zanesville and Cambridge.

The presidents of the three Societies introduced their members and the program was turned over to the Speaker, Mr. John A. Duhy, of Ohio State University. His topic was **China and Its People.** The speaker lived in China for many years and also served in the Artillery of Chiang Kia Shek's army in Formosa.

The speaker pointed out some of China's old history and explained some of their customs and how they arrived to the different characters in the Chinese language. The speaker was very interesting and highly applauded. There were approximately 120 people present, about 16 members of our society.

Miami Valley

Ultra-Sonic Machining Process Operation is Described

M. V. Roode

On the evening of March 1st, 32 members and friends of the Miami Valley Section S.P.E. were guests of the Sheffield Corporation in Dayton, Ohio, for a demonstration of their new ultrasonic machine tool, the Cavitron.

Mr. Jack Welch, Gen. Mgr. of Sheffield's Machine Tool Division, very briefly outlined the varied products and services available through their organization that give meaning to their slogan "manufacture and measurement for mankind."

Of primary interest to the group was the slide illustrated explanation of ultrasonic machining and the demonstration by Mr. George Brown, of the Cavitron Division. However, the wide range of "Precisionaire" and "Plunjet" gages, "Airetest" indicators and precision machine tools on display were examined quite thoroughly by all present.

According to Brown, ultrasonic machining now provides industry with a long sought means of cutting hard materials quickly, economically, to close dimensional tolerances and with excellent surface finishes.

Specifically, advantages to be gained in the use of the Cavitron are:

1. Materials such as hardened tool steel, carbides, glass, ceramics, gem stones, germanium, magnetic ferrite, carbon and some of the hard-high density plastics may be readily machined by this method.
2. Machining time can be cut by forming profiles in hardened work pieces, and perhaps permit solid section design to replace conventional split sections in many applications.
3. Reduction of hand polishing time.
4. Eliminates possibilities of thermal cracks, localized annealing and internal stresses in the hardening of intricate forms after conventional machining.
5. Salvage of tools and dies in engineering changes without the danger of annealing.

The ultrasonic machining action is very simple, Mr. Brown pointed out. Cutting is done by abrasive grains driven into the work piece by linear oscillation of the required tool. The high velocity with which the grit strikes the work piece machines away microscopic particles of the material without producing any perceptible heat.

The abrasive grains used are the same types and grit sizes as used in commercial grinding wheels except that here they are carried, in granular form, in a liquid medium that flows between the work piece and the tool. The fluid is recirculated for continued use. The type and grit size are selected in accordance with the nature of the operation and with the surface finish desired. The abrasives normally used are boron carbide, silicon carbide and aluminum oxide.

Bombardment of the work piece by the abrasive grain is accomplished with a tool stroke of only a few thousandths of an inch but with a linear oscillation of approximately 20,000 times per second. The shape of the tool determines the precise bombardment pattern of the grit against the work piece.

The extremely fast motion of the tool face produces cavitation of the abrasive liquid carrier and the liquid turbulence keeps the abrasive grains in constant action. The turbulent action also acts as a pump producing circulation of the liquid for washing out the minutely cut particles of the work piece.

The basic units that comprise the Cavitron are:

1. An electronic generator, in a portable cabinet that converts 110 or 220 volt A.C. into high frequency power.
2. A transducer and tool holder. The transducer converts the electrical energy into mechanical energy which is transmitted to the tool through the tool holder causing the tool to oscillate at high frequency. The transducer can be mounted on any machine base that satisfies the required machining accuracies.
3. The abrasive pump, a recirculating pump that supplies the tool and work piece with abrasive grains suspended in a liquid.

Tools for the Cavitron transducer are made preferably of alloy steels although brass and hard copper may be acceptable in certain applications. Tool size is governed by the degree of accuracy and type of finish required. The machining capacity, that is tool cross sectional area, is limited by the power capacity of the transducer. The largest transducer at present is capable of machining a $4\frac{1}{2}$" hole.

Machining rates are governed by two factors, hardness, brittleness or density of the work piece and coarseness of the abrasive grains. The more brittle the material and the coarser the grit the faster the stock is removed.

In roughing operations, a 25 microinch finish may be obtained with 280 grit. Finer finishes may be obtained by using up to 800 grit.

Tolerances of .002" are generally obtained with the 280 grit while tolerances of .0005" or better may be obtained with finer abrasives as a secondary operation. In general, maximum precision and smoothness of finish are attained by the use of more than one tool and more than one grit size for any profile cut.

An extremely interesting sidelight of this S.P.E. visit to the Sheffield plant was the opportunity to see their new "Eli Whitney" metrology lab, a laboratory where environmental control is accurate to 1/20 of 1°F. of temperature, barometric pressure is corrected for temperature of the mercury, elevation above sea level, and the gravitational pull of the earth at the Dayton latitude. Even body heat of the operator is considered and where accuracies of measurement, parallelism and planeness of surface, as measured by the constant wave lengths of helium, cadmium, Krypton or mercury 198 with an absolute interferometer, may be certified to .000002 to .000005 inch.

This is probably the first industrial lab in the world to attain accurate enough environment controls to offer certification of measurements in millionths of an inch.

Milwaukee

Injection Molding

W. H. Brueggemann

Another outstanding program was presented at the March meeting of the Milwaukee Section of SPE. Bill Gobeille, our Program Chairman, introduced Mr. Gordon B. Thayer, of the Dow Chemical Company, Midland, Michigan, who spoke on the subject, "Injection Molding."

Two movies were viewed which showed action shots of injection molding, inside the mold, using polystyrene or polyethylene. High speed injection produced the most desirable products. Molding phenomena such as jetting, shrinkage, sink marks, flooding, withdrawal and welding were viewed by the action shots in the mold. A hot mold was found to be helpful along with high speed injection for producing a good product containing inserts.

Mr. Joe Eveland, also of the Dow Chemical Company, spoke briefly on the potential market of polystyrene. Improved polystyrenes are forthcoming and will show better flow properties, physical properties, and heat resistance. Copolymers also are showing marked improvements in properties and some are transparent. Other materials containing polystyrene are under development.

Cleveland-Akron

Tooling for Thermoplastics

R. M. Hershey

Mr. N. C. Taylor, Service Engineer for Eastman Chemical Products, Inc., addressed the March 12 meeting of the Cleveland-Akron Section SPE. Approximately 65 members attended the meeting which was held at the Spanish Tavern in Brecksville, Ohio.

Mr. Taylor showed a color film of some injection molding operations at the Rochester, N. Y., plant of Eastman Kodak. Mr. H. D. Oliver, Jr., our Section President, who is also with Eastman Chemical Products narrated the film. The film stressed safety precautions which may be taken in injection molding operations. The film showed a possible arrangement for injection molding with no need for the operators ever to put their hands between the press platens. Parts could be removed by the use of tongs and elaborate safety devices could be installed to prevent access to the cylinder heaters while the press is in operation and yet permit access for repair purposes.

This film is recommended for injection molders. Even though most molders will not wish to go to the extremes in safety precautions suggested by the film, the film may prompt the molders to take a possibly much needed review of their own safety precautions.

Following the film, Mr. Taylor discussed "Tooling for Thermoplastic Molding." He recommended highly hot nozzle mold construction for use with the cellulosics or polyethylene.

In hot nozzle mold construction a long heated nozzle is brought as close as possible to the finished part in the mold. The sprue length is consequently shortened and the material is delivered to the cavity as hot as possible since it is not cooled by flowing through a long sprue. Mr. Taylor stated that excellent results were being obtained with the hot nozzle mold construction using cellulosics, polyethylene, and acrylics. In several cases the hot nozzle mold construction has been successfully substituted for hot runner mold construction which often gave trouble with cellulosic materials.

Full round runners were recommended for the cellulosics and polyethylene. Trapezoidal runners in one half of the mold were also recommended as being almost as satisfactory.

Mr. Taylor recommended that the runners be no longer than one eighth of an inch in diameter even for molds as large as sixteen cavities. He said that there was no need for large runners with the cellulosics or polyethylene. Less scrap material fewer welds and shorter cycles were cited as the chief advantages of the small runners.

A land length of .030 beveled in two directions was said to permit the use of a gate as small as .016 to .022 inches in diameter for many parts.

The importance of an obstruction within 3/16 inch of the cavity entrance in preventing cold flow lines was emphasized. If no obstruction is present, the material will jet across the cavity and cool off quickly. The cooled jet subsequently may form a cold flow line in the finished part.

Prior to Mr. Taylor's discussion our membership chairman, Mr. C. W. Virgin, Spencer Chemical Co., introduced the guests who were present at the meeting. Our President Mr. H. D. Oliver, Jr. announced that Mr. J. R. Jones, Claremont Co., would serve as chairman of the annual June golf outing.

Kentuckiana

Award to be Presented

R. O. Carhart

The regular monthly meeting of the Kentuckiana Section of the SPE was held Wednesday evening, March 21, 1956 at Bauer's Restaurant, Louisville, Ky. with approximately 30 members and guests in attendance.

After an enjoyable meal, a short business meeting was held at which the various committee chairmen gave brief reports on their activities to date. Bob Millar pointed out that the Achievement Award, which is to be made to the member of our group selected as having made the outstanding contribution to the plastics industry during the past year, is to be presented to the winner at our May meeting. He also urged that all nominations be submitted as soon as possible. Ed Roberts showed a drawing of the award placque which he is designing.

Program Chairman Clem Young then introduced Mr. M. A. Self, President of Logo, Inc., Chicago, Ill., who discussed "The Decoration of Plastics." Mr. Self's talk covered composition of lacquers and paints for plastics, function of the various components in the formula, film properties, and film defects. His talk, which was accompanied by illustrative slides, was concluded with an outline of defects which could be encountered in a vacuum metallized film. A short question period was then held and several samples of some of the defects encountered in the decoration of plastics were shown.

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What harm could come from local people being enough interested to defend themselves against the advocates of violent overthrow of Government? Do we have to wait for permission from Washington to put the burglar out of our house? Haven't we too many examples of where Bureaucratic Washington is too busy to act? Don't we need less rather than more Federal controls? Are all the State Attorney-Generals wrong when they opposed the decision? Why don't you write your Congressman and give him your view?

Yours for Better Living with Plastics,

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WAYNE I. PRIBBLE, President

Upper-Midwest

Regional Conference Planned for Fall; Plastic Fair Set for May

F. W. Brown

The Upper Midwest Section of the Society of Plastics Engineers is going to sponsor a one day technical meeting on "Polyurethanes." This session will be held on October 23, 1956 at the Curtis Hotel in Minneapolis, Minnesota.

Anyone interested in presenting a paper is requested to submit an abstract of their talk by June 15. These abstracts are to be sent to the Society of Plastics Engineers, 711 Second Avenue South, attention of Miss Polzin, Chamber of Commerce, Minneapolis, Minnesota.

Fields of interest suggested for this session include — (1) Equipment, (2) Uses, (3) Chemistry, (4) Compounding and (5) Future of Isocyanate based materials.

One hundred local plastics manufacturers and processors will have the opportunity to submit samples of their products for display at a Plastics Fair sponsored by the Upper Midwest Section of the Society of Plastics Engineers on May 21. Mr. Paul Felt, Fair Committee Chairman, reviewed progress made on fair arrangements at the Society's March meeting. Exhibits volunteered by companies of the Upper Midwest Section will be viewed at the Prom Ballroom in St. Paul where people engaged in the plastics industry can become acquainted with other plastics activities in this area. A dinner and program featuring guest speaker Brook Stevens, nationally known industrial designer, will climax the evening.

The subject for the Upper Midwest regional technical conference scheduled for October 23 will be polyurethanes. Mr. William Jarvey is heading the convention. Speakers will be selected on a nation-wide basis.

The March 21 meeting of the Upper Midwest Section was attended by a near record 56 members and friends who turned out to hear Mr. George Sollenberger speak on high density polyethylene. Mr. Sollenberger is Technical Coordinator of Plastics Market Development at Koppers Company. Mr. Sollenberger pointed out the inadequacies of the various names, including high density polyethylene, that have been applied to this new polymer. Koppers' product will be known as "Super Dylan."

The properties of high density polyethylene differ so widely from conventional polyethylene that it must be considered a new polymeric material that will find its own area of uses. Its high density, good low temperature impact strength, high distortion temperature, high tensile strength, high modulus, good abrasion resistance, good chemical resistance, and low permeability has resulted in high density polyethylene being used in washing machine agitators, wire insulation, plastic pipe, refrigerator parts, chemical bottles, medicine droppers, lawn mower wheels, rope, battery cases and toys. Mr. Sollenberger also pointed out areas where high density polyethylene was not suitable. For example, high density polyethylene is not extremely hard and, therefore, of limited usefulness in products such as dishware which require high abrasion resistance.

Baltimore-Washington

New Polyethylenes are Described

William C. Rainer

The March meeting took place on the 13th at 8 P.M. in the Langley Park Hot Shoppe banquet room near Washington, D. C. The meeting was preceded by dinner at 7 P.M. Forty-five members and guests attended.

President Irv Wolock opened the meeting by reminding the group that the Annual Technical SPE Conference would be held in Washington in 1961, and that the committee would submit its recommendations on hotel facilities within the month. He also requested that additional signatures be obtained to augment petitions to the National Council for the establishment of professional activities groups. These groups would specialize respectively in: fabrication, finishing, forming extrusion, laminating, injection molding, plastic electrical insulation, encapsulating and injection molding.

George H. Sollenberger of Koppers Company, Inc. highlighted the evening's activities by a talk on "The New Polyethylenes." By a series of color slides and photomicrographs, he spelled out in pictures the use pattern and crystalline character of these new members of the plastics family. He bemoaned industry's dilemma in nomenclature, some of the names being: polymethylene, high temperature-, high tensile-, high density-, low pressure-, linear-, super-polyethylene.

He reasoned that reduction in the number of side chains in the polymer molecule facilitates packing or crystallite agglomeration, whereas an increase in the number of branch chains induces amorphous tendencies. The latter condition is characteristic of the conventional polyethylenes. Mr. Sollenberger cautioned against slow cooling of a crystallite, such as high density polyethylene, since agglomeration tends to develop thereby with consequent environmental cracking. He also pointed out that infra red would not differentiate between the two type polyethylenes.

Mr. Sollenberger commented on the abrasion resistance of filaments made from the new polyethylenes and indicated their superiority over nylon in this respect. In fine he enumerated possible uses for the new polyethylenes, viz: pipe, pipe fittings, battery cases, refrigerator parts, wire insulation, fish nets, aerosol containers, and the like.

Northern Indiana

Developments in New Silicones

W. W. Wareham

The Northern Indiana Section of the Society of Plastics Engineers held a dinner meeting at the Chamber of Commerce in Fort Wayne, Indiana on March 12th.

The speaker of the evening was Dr. David Spalding of the Silicone Products Department of General Electric Company. His talk entitled "New Developments In Silicone Rubber" consisted of interesting highlights in the history of silicone elastomers and particular emphasis was given to types of formulations, compounding and new applications for silicone rubber. Part of his presentation consisted of an interesting sound film showing the simplicity of silicone rubber compounding with its inherent advantages to the manufacturer.

Pacific Northwest

Boeing Describes Business Program

Richard T. Davidson

Left to right: James W. Gilman, vice - president; Burton A. Cole, President; and Richard T. Davidson, Secretary-Treasurer.

The meeting was called to order by President, Burton A. Cole.

The guest speaker, Mr. Joe Miles, Assistant Material Manager of the Boeing Airplane Company, was introduced by Mr. Cole. Mr. Miles spoke on the procurement practices of the Boeing Airplane Company.

Most of the people present represented a variety of companies which have done business with the Boeing Airplane Company at one time or another; and all agreed that Mr. Mile's talk was very interesting and informative. He discussed the financial responsibility of the parent company's obligation to the military. He also advised that they do business in 46 states and have a group of men that are constantly traveling throughout the nation evaluating the subcontractors who are to fulfill their obligations. They are likewise interested in products of these subcontractors. Boeing also from time to time assists the suppliers on particular projects, provided these organizations have the proper personnel to undertake a new program.

In closing, Mr. Miles discussed the dollar volume done with the subcontractors, and the amount of outside purchases that are required by the military, even though in some instances they are capable of performing the work themselves.

After Mr. Miles' speech, there was a general discussion among the 35 present, and Mr. Miles was most cooperative in answering all questions.

Pacific Northwest Section officers are: President, Mr. Burton A. Cole; Vice-President, Mr. James W. Gilman; Secretary & Treasurer, Mr. Richard T. Davidson; National Director, Mr. Borris V. Korry; Section Directors, Bruce H. Bettcher, Burton A. Cole, Borris V. Korry, Marvin E. Carr, Leonard M. Purdue, Leonard J. Vaupell, Jr., Richard T. Davidson, James W. Gilman, Robert A. Fulton and Merrill R. Roth.

Committee Chairmen are: Membership & Credentials, Mr. Don La Gassey; Program & House; Mr. James W. Gilman; Publicity & Educational, Mr. Leo Siers; SPE JOURNAL Reporter, Mr. Richard T. Davidson.

Regular meeting night is the Third Friday of each month at The Norselander Restaurant.

Toledo

Reinforced Plastics Topic

C. A. Richie

Thirty-eight members and guests of the Toledo section of S.P.E. gathered for a dinner meeting at Angelo's Spaghetti House on Wednesday evening, March 21, 1956.

The short business meeting that followed found all members in favor of continuing with the dinner-speaker type of meetings with an occasional field trip added. Many members commented on our excellent technical magazine, The S.P.E. Journal.

Our speaker of the evening, Mr. Paul Fina, Technical Sales Manager of Fiberite Corporation, Winona, Minnesota, discussed the subject, "Practical Evaluation of Reinforced Thermosetting Plastics."

He emphasized the importance of the correct selection of reinforced compounds for specific applications. The use of reinforced compounds oft-times permits use of thinner walls with reduction by ½ of weight per piece. Machining costs on such as laminated block can be greatly reduced if the piece can be molded.

Mr. Fina said the molder is generally faced with such questions as:

1. Properties desired vs. price.
2. Should thermosets be used?
3. Is strength needed?
4. Is dimensional stability needed?
5. Is abrasion and corrosion resistance needed?
6. Is cold flow a factor?

No one compound answers all applications. The type resin and kind of filler will produce varied properties and must be considered and chosen carefully for optimum end results.

The phenolics, melamines, and polyesters (alkyds) are the resins generally used.

The fillers can be asbestos, glass fiber macerated fabrics (shirt material), sisal, Nylon cord, paper, and the like.

Mr. Fina cited use of fabric filled thermoset compounds in steel mill bearings, conveyors buckets, and airplane pulleys where they outperform metal. Serving trays are another excellent example for use of reinforced compounds.

Using the serving tray as an example, Mr. Fina pointed out that the bulk factor will run about 6:1; this means that the 3/16" molded tray will require a 1-1/8" deep mold. Where preforming is done the ratio is lowered to about 2½:1. Optimum molding pressure should always be established.

It was apparent after hearing Mr. Fina that their compounds are well established and they are finding an ever increasing market as molders become more aware of need for greater durability and stability in certain end products.

S.P.I. Programs For 1956

May 1—SPI will be located in its new offices at 250 Park Avenue, New York 17.

June 11-15—Seventh National Plastics Exposition, New Coliseum, New York City, and SPI Conference and Annual Meeting, Commodore Hotel, New York City.

June 26—SPI Plastic Structures Division Conference, Hotel Roosevelt, New York City.

October 11, 12—SPI New England Section Conference, The Wentworth Hotel, Portsmouth, N. H.

December 4, 5—Seventh SPI Film, Sheeting and Coated Fabrics, Commodore Hotel, New York City.

Eastern New England

Zytel, Vacuum-Forming, Phenolics Provide Varied Meeting

Alfred I. Simon

A joint meeting of the Eastern New England Section and Southern New England-Providence Chapter of the S.P.E. and the Boston-Providence Chapter of the S.P.I. was held at the Lafayette House in Foxboro, Massachusetts on March 15, 1956. Approximately 130 members and guests jammed the dining area.

The outgoing president of the Eastern New England Section, Harry Connors of B. F. Goodrich Company, introduced the new president, Ralph L. Mondano of Raytheon Manufacturing Company. He in turn introduced the new slate of officers.

An award of a savings bond was presented to Gim P. Fong as the producer of the most new members during the recent membership drive.

Mr. Fong, who is chairman of the Program Committee, then introduced the first speaker, V. S. Bowers of duPont. Mr. Bowers presented a very interesting dissertation on design properties of "Zytel" nylon resins. He also presented slides of graphs dealing with modulus of elasticity of "Zytel" vs. temperature under different humidity conditions, change in dimensions vs. moisture content, moisture gain vs. time for different diameters and relative humidities, deformation vs. time for specified compressive and tensile stresses, and tensile strength vs. temperature under varying humidity conditions. After the talk, literature on all this was distributed to the audience.

Mr. Sanford S. Zimmerman of Vacuum Forming Corporation then spoke on the vacuum forming process and applications, most specifically, future potentials. He discussed the advantages and disadvantages of vacuum forming over injection molding, stressing particularly advantages of relatively low cost molds, versatility in mold design changes and especially short runs.

After the door prize drawing, a 16 mm. sound film, "Molding of Phenolics," was presented by Bill Nissen of the Bakelite Company.

BOARD MEETING

A special meeting of the Board of Directors and new committee members of the Eastern New England Section was held on February 14, 1956 at the Pillar House, Newton, Massachusetts. The new officers are: President, Ralph L. Mondano of the Raytheon Manufacturing Company; Vice President, Frederick P. Quarterone of the Bolta Products Company; Secretary, Josiah D. Crosby of the Hood Rubber Company; Treasurer, David W. Towler of the M. W. Kellogg Company.

Richard W. Beckwith of the Dow Chemical Company remains as National Director.

The Section Directors include Professor Albert G. H. Dietz of M.I.T.; George P. Kovach of the Foster-Grant Company; William C. Nissen, Jr., of the Bakelite Company; R. Moen Smith of the Bolta Products Company; Robert S. Ward of the Improved Machinery Company; Josiah D. Crosby, Ralph L. Mondano, Frederick P. Quarterone, and David W. Towler.

Committee Chairmen are as follows: Membership, Joseph P. Clancy of Emery Industries and Robert S. Ward; Credentials, Frederick P. Quarterone; Nominating, Frederick Langhorst of Stanley Chemical Company; Finance and Auditing, William L. Root, Jr. of Raytheon Manufacturing Company; Program, Gim P. Fong of Raytheon Manufacturing Company; House, William C. Nissen, Jr.; Publicity and S.P.E. Journal Reporter, Alfred I. Simon of Raytheon Manufacturing Company; Educational, Professor Russell W. Ehlers of Lowell Technological; Professional Activities, Walter W. Peacock, Jr. of National Research Corporation.

A program for the coming year was highlighted in a written report prepared by the new section president. Some of the highlights of this report were:

A goal of 25 per cent increase in membership during the coming year.

Suggestions for increasing membership, such as reduced initiation fees and a prize incentive for the individual obtaining the most members.

Possibility of organizing a student branch.

The Finance and Auditing committee will do long-range planning for the expenditure of money for the furtherance of both the S.P.E. and the plastics engineer in industry.

The Program Committee will investigate openings for summer placement of students and for planning trips to plastics manufacturing companies.

The setting up of a New England Society of Plastics Engineers Conference will be the responsibility of the Professional Activities committee. Topics that were suggested for this conference are: "Plastics in the Electronics Industry," "Plastics in Building," "Education in Plastics," and "Design Limitations in Plastics."

The carrying out of this program will certainly require the cooperation of not only the local membership but also of the several New England sections.

Southern

Hi-Impact Forming and Molding

John W. McCauley

An outstanding meeting of the Southern Section was arranged this March by Mr. Norman A. Harris of the Monsanto Chemical Co. Thirty-five members were privileged to hear Mr. William E. Welsh of the Monsanto Technical Service Plastics Division discuss with slides "The Extrusion and Vacuum Forming Techniques of High Impact Styrene." The final part of the meeting was a 20 minute color movie by Monsanto, "The World that Nature Forgot."

Mr. Welsh pointed out that in 1955 somewhere between 25 and 30 million pounds of polystyrene were processed by the vacuum forming technique, a figure that is rapidly challenging injection molding in industrial significance. About 50% of this figure was used by the major appliance manufacturers in such applications as refrigerator and freezer door liners. Interesting to note too is the fact that with the development of this new plastics forming technique, many of these major manufacturers have made their entry into the plastics processing industry.

With his slides and talk, Mr. Welsh illustrated the various details of the extrusion of high-impact styrene sheet and the three main current methods of coupling the forming and extrusion operations. These forming techniques were graphically named the In-Line extrusion forming, the Ferris Wheel and the Merry-Go-Round. All three methods were adaptable to straight vacuum forming, drape forming and vacuum forming with plug assist. Mr. Welsh also commented that with certain of these combinations, some manufacturers had been able to achieve a 70 second forming cycle, a point of great significance to any large volume producer.

"The World that Nature Forgot" is a highly professional presentation of the role of polymeric chemistry and the plastics industry in our life today and tomorrow. It has high educational value for industrial and service groups not yet dealing directly with plastic materials and is available at no charge from the Monsanto Chemical Company.

Western New England

Industrial Design Topic

C. P. O'Donnell

The March dinner meeting of the Western New England Section, held in the Terrace Room of the Bradley Air Field Administration Building, featured a talk on Industrial Design by Professor John E. Alcott of the Rhode Island School of Design. Professor Alcott's topic was, "The Bearing of Industrial Design to the Plastics Industry." Al Shunaman, C. F. Church Manufacturing Company, served as program chairman and introduced the speaker.

The first portion of the talk covered Industrial Design from its inception, with "stylists" and "cubism," to its present position described by the speaker as a "potent adjunct to life." Drawing on his own extensive experiences as owner and director of Alcott Associates, designer for Bird & Son, Inc., J. Donnelly & Sons, Massachusetts' New York World's Fair Exhibit, and advisor to organizations such as Associated Industries of Massachusetts, the speaker liberally punctuated his talk with personal anecdotes and stories.

Starting with the "stylists" and their design theory of cubism, both of which were an expression of the American reaction to the European lead in design as exhibited in the Paris Exposition about 1925, the Professor gave a brief history of the industrial designer. Originally called stylists, a name now applied only to the automobile field where style is imposed on engineering design, these early designers were called upon to "face-lift" an engineeringly perfect but esthetically unpleasing design. These men, actually architects, or painters, working in a field which was a distant relation to their chosen vocations, had no formal industrial design training.

Cubism was then replaced by "simplicity," an economy of design underlining the frugality of the depression era. As plastics came into their own, and after the initial spurt of aping wood or metal for its sake alone had died out, the form of the material served the design purpose. At this point form was the exciting thing.

As industry developed in the post-World War II period, so did molding techniques and materials. This, in the last few years, has brought industry and the industrial designer to the point where they, as Professor Alcott put it, "can now make them, (manufactured items) look as good as they are. Now the trick is to make them function as good as they look."

This, then, is the new function of the industrial designer—the trained man for the job at hand. Though, according to the speaker, the industrial designer reflects the culture of his time, serving to raise mass culture, and acting as a prophet for the new and radical thoughts about him, he must go beneath the esthetic surface of design and apply his trained creative mind to developing the functional aspects of goods and items. The designer is now entering into another and connected field, that of distribution. This entails the moving of a product into the consumer field, and winning acceptance for it through its own inherent esthetic and functional design attraction.

The latter half of Professor Alcott's talk was devoted to the steps taken, and methods used, by an industrial designer in the outlining and completion of a job.

The most important point is the compilation of complete data. To this end there are questions which must be answered as to the type of buyer, type of goods, purpose, demand intensity, buying mood, the fundamental desire that is to be satisfied (hunger, thirst, sex, security, aggressive, elemental senses, and esthetic senses), where and when the product is sold, and with what frequency and regularity.

Here the Rhode Island School of Design professor distributed two check lists. One listed the above questions, with spaces for appropriate comments. The other, through a highly developed coding system, touched on 22 major points of marketing, performance, physical form, and production. When keyed, the designer could see which of these 22 points should receive major consideration in design development.

Golf Chairman Walter Clark has arranged for the annual Golf Outing, a stag affair to be held at the Manchester (Conn.) Country Club on June 8th.

Central Ohio Golf Outing

The Central Ohio Section will have a golf outing on June 19th, at the Circleville Country Club.

Dinner will be served at 7:30 P.M. Prizes will be awarded for achievements of the day.

After dinner a talk will be given by Ernest Moslo, President of the Moslo Machinery Corporation, Cleveland, Ohio.

All S.P.E. members are invited to attend.

For additional information, contact Victor Hauprich, Secretary of Central Ohio Section, 142 Parsons Avenue, Columbus, Ohio.

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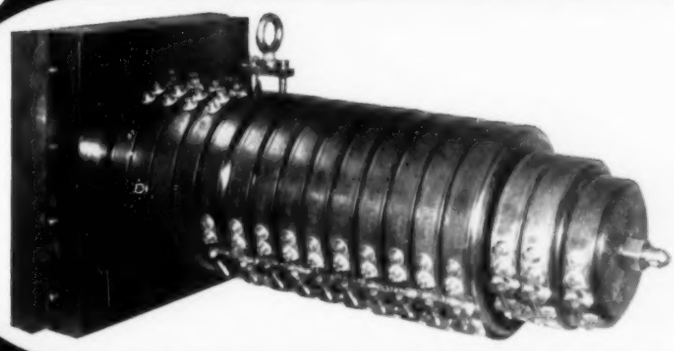

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book reviews

PLASTICS TECHNICAL DIRECTORY VOL. I
by A. M. Wittfoht. Published 1956 by Carl Hanser Verlag, Leonhard Eck Strasse 7, Munich 27, Germany. 42 marks. 389 pages.

This English-German plastics dictionary will be very welcome to everyone who does business with German companies, or who corresponds with them. It will be an invaluable aid to the American readers of German articles dealing with plastics.

The book is precisely what its title implies, a complete set of plastics terminology in all phases, each word followed by its German equivalent. This is followed by sections describing in both languages, the processes of fabricating film and sheet, mixing and molding; a section of abbreviations, and an extensive conversion table of English and metric units.

The book is nicely bound in plastic covers, is well-printed on good paper, and gives every evidence of being complete and authoritative, as well as easy to use. A second volume, German-English, is on the way.

Jesse H. Day

"BRITISH PLASTICS YEAR BOOK 1956: A Classified Guide to the Plastics Industry." 26th Edition. Published on 1st March, 1956 by Iliffe and Sons Ltd., Dorset House, Stamford St., London S.E.I, England. Price 35s. 0d. net. (postage 1s. 9d.) Size 9¼" x 6¼".

British Plastics Year Book remains the only classified guide to products and manufacturers in the plastics industry, and this year it has been revised and extended to 740 pages. As before, it is divided into nine sections of which three are devoted to classified lists of manufacturers and suppliers of materials, finishing products and equipment. A further section contains the world's largest list of trade and proprietary names connected with the plastics industry, covering materials as well as finishing products. Each trade name is followed by a definition of the products, the manufacturer concerned, and, where the manufacturer is overseas, the country of origin. A glossary of technical terms used in plastics is also included in this section.

In the names and addresses section are listed nearly 4,000 firms associated with plastics, grouped into countries. Names and positions of prominent people in the industry are given in the Who's Who section.

The annual review of plastics patents is again featured and this year this important section contains 184 pages. All relevant patents issued during 1955 are collected, abstracted and arranged by experts in subject groups —amino plastics, cellulose plastics; ethenoid resins; thermosetting ethenoids; phenolic plastics; polyesters; silicon resins; super polyamides; and plastics machinery. Prefaces to each group give a brief review of the year, thus making this Patent Abstracts section an indispensable record of technical developments as shown in the patents literature.

New plastics companies registered last year are

listed; details provided include the official date of registration, address, activities, capital and directors. The general index gives quick reference to any product or subject in the year book.

The up-to-date information packed in this volume provides a unique reference book for manufacturers, buyers and sellers of plastics materials and goods, and for makers and users of machinery and equipment.

Contents include: Review of recent patents; New companies registered in 1955; Specifications relating to plastics; Guide to plastics material suppliers; Guide to plastics product manufacturers and plastics processors; Guide to equipment suppliers and to services; Directory of trade and technical terms; Names and addresses of firms grouped in countries, and of organizations, consultants, etc.; Who's Who; Trade associations; Technical and general data; General index.

Discussion On The Maccaferri Heating Cylinder

(Original article appeared in SPE Journal for Feb., 1956)

"Have you molded methyl-methacrylate in this cylinder?"

"Have you tried vinyl compounds; have you experienced trouble in burning?" If so, how much difficulty in cleaning the cylinder?"

"Has the cylinder been checked out with various thermoplastics? (Styrene, vinyl, polyethylene). Does it perform differently with each?"

"How would heat-sensitive polymers of high melt viscosity, such as PVC, mold with a Maccaferri heating chamber?"

"Can color changes be made easily?"

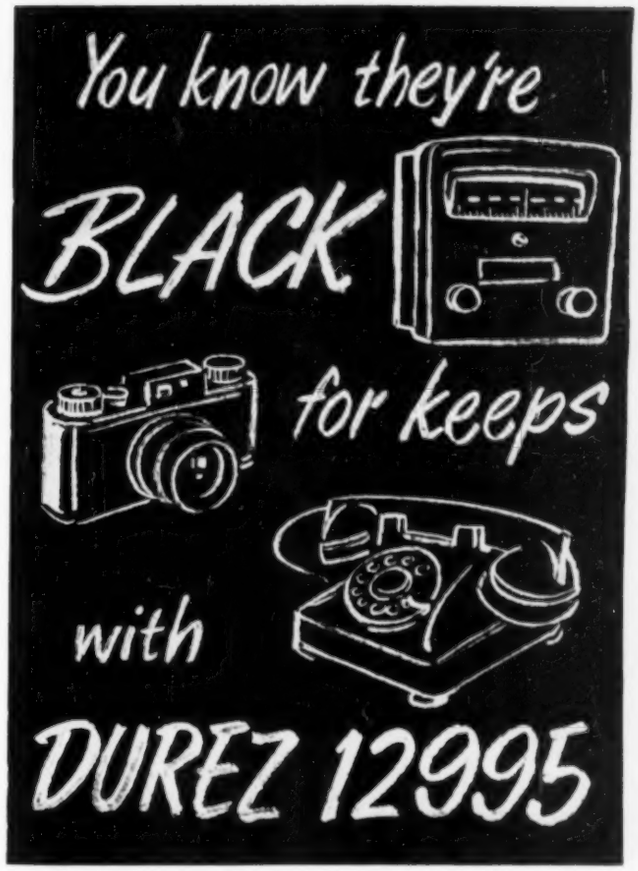
"Would there be trouble with material getting stuck in the Maccaferri heating chamber and causing streaks in light colored materials? Will the chamber purge clean from one material to another?"

The Maccaferri heating chamber has so far been used only on polystyrene. Color change is no problem; in production, color is changed about three times a day. Start-up on Monday morning has not shown any symptoms of hangup or hot spots. True, polystyrene is a relatively docile molding material. But the problem is basically the same with any thermoplastic; it must be heated to its molding temperature with the greatest possible uniformity and the smallest possible pressure loss. While experience will undoubtedly show that changes in detail are desirable to get optimum performance with each type of plastic, a better heating chamber is a better heating chamber, whether it be used on polystyrene, polyethylene, ethyl cellulose, or saran.

"What is the danger of overheating the material in grooves prior to sufficiently heating the material on the primary heating surface?"

I assume you are concerned with the unavoidable temperature gradient between the heater barrel and the primary heating surface, which must be cooler because the heat flows through the sleeve to get to the primary surface. The best thing about this new type of heater is that it allows us to mold a competitive cycle without the need for excessive heater temperature. The material will stay in the grooves for only the length of one cycle, so that even though the temperature of the grooves is 10-20°F higher than that of the primary surface, this temperature need not be high enough to damage the plastic.

(Please turn to page 58)



When plans call for a black surface with a rich, velvety luster that years of rugged service will not dim, Durez 12995 is your number.

The long-lasting beauty of this phenolic material makes it unequalled for camera cases, telephone hand sets, instrument housings and the like. It resists dulling and pimpling caused by moisture and body acids, and retains its fresh-from-the-mold appearance through long periods of rough handling. If machining and sanding are necessary, molded parts regain their original luster when buffed.

Durez 12995 is a two-step general-purpose material with higher impact than other molding compounds of its class, a characteristic that has helped to keep molding machines busy ever since it was introduced by Durez. If you are working with or are likely to work with jobs of the types mentioned, make sure you have specifications and further details about this material. Drop us a line and ask for the current data sheet on Durez 12995.

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Central Indiana

Injection Molding

C. R. Smith

On Tuesday evening, March 27, the regular monthly meeting of the Central Indiana Section was held at the Warren Hotel, Indianapolis, Indiana. Fifty-nine members and guests heard Richard W. Miler from Dow Chemical Company introduce a new Dow film entitled "Inside the Injection Mold with Polyethylene." The introduction and film were very well received. An interesting question and answer period followed.

Frank Reinhart Is A.S.T.M. Chairman

Mr. Frank W. Reinhart, Chief of the Plastics Section of the National Bureau of Standards, was elected Chairman of the Committee on Plastics of the American Society for Testing Materials at their meeting in Philadelphia, Penna., on February 17, 1956. Other officers elected were A. C. Webber of the DuPont Company, First Vice Chairman; Professor A. G. H. Dietz of the Massachusetts Institute of Technology, Second Vice Chairman; J. B. DeCoste of the Bell Telephone Laboratories, Secretary and R. H. Carey of the Bakelite Company, Membership Secretary.

As Chief of the NBS plastics laboratory, Mr. Reinhart directs the Bureau's research, development and testing program on organic plastics, coatings and adhesives. This work is needed for the technological advancement of various plastic materials for use in industry. Mr. Reinhart is author and co-author of some 30 technical papers on various plastics, effects of resins and catalysts on wood lamination, reinforced plastics, adhesion and adhesives, airplane dopes, plastic films, permanence of plastics, chemical resistance of plastics, methods for testing plastics and adhesives, and standards and specifications for plastics materials.

The American Society for Testing Materials is one of the foremost standardizing bodies in the world. They are concerned with the promotion of knowledge of the materials of engineering, and the standardization of specifications and the methods of testing. The Committee on Plastics has developed more standards on plastics than any other organization in the world. Many new standards are currently under development.

Born in Bellwood, Pennsylvania in 1907, Mr. Reinhart received his Bachelor of Science degree **summa cum laude** from Juniata College in 1930 and has taken post graduate courses at Columbia University and the University of Maryland. He was a member of the faculty of Juniata College where he taught chemistry from 1930 until he joined the NBS staff in 1937. He received the Superior Accomplishment Award of the Department of Commerce in 1946.

Mr. Reinhart is an active participant in many organizations. He is past Chairman of the American Society for Testing Materials Committee D-14 on Adhesives, and a member of the Executive Committee of the Thermoplastics Structures Division of the Society of the Plastics Industry. He is a past National Secretary and National President of the Society of Plastics Engineers and is currently a member of their Executive Committee. He is also a member of the American Physical Society, American Association for the Advancement of Science, The American Chemical Society, The Chemists Club, and the Washington Academy of Sciences. He was Chairman of the 1955 Gordon Research Conference on Adhesion.

Synvar Announces Phillips Promotion

Synvar Corporation of Wilmington, Delaware announces the promotion of Mr. Forrest E. Phillips to the position of Sales Manager of their Phenolic Molding Compound Department.

"Phil," as he is known to the trade, spent practically his entire career in the molding industry, starting in 1934 with the S. S. White Company where he became Superintendent of the Molding and Rubber Departments. In 1946 he became associated with Northeastern Molding as General Manager where he was involved in purchasing, mold design and production of custom compression and injection molding.

After spending three years with Delaware Chemicals, Inc. as Project Engineer, Phil returned to the molding industry when he became associated with Synvar Corporation in 1954.

Escambia Research

The appointments of Horace W. Boynton and W. Mayo Smith, Jr., as Assistant Directors of Research for Escambia Bay Chemical Corporation were announced today by Dr. N. C. Robertson, Director of Research.

Dr. Smith will be in charge of polymerization and plastics research and development.

Koppers Design Contest Winners

Five potential product design leaders of the future will benefit from the top awards made by Koppers Company, Inc., at a dinner in the William Penn Hotel honoring winners in a nationwide Design Competition for molders of plastic housewares.

Top prizes in the Competition are four one-year, full-tuition scholarships, and one two-year, full-tuition scholarship in the names of the winning molders in each of four Competition classifications, and the molder of the item judged "Best of Competition," respectively.

First-prize winners were: Federal Tool Company of Chicago, Illinois; C. B. Cotton & Co., Inc., Brooklyn, New York; Bu-Gay Plastic Products, Inc., Chicago, Illinois; and Columbus Plastic Products, Inc. Columbus Plastic also was awarded the "Best of Competition."

Federal Tool announced that its scholarship would go to the Illinois Institute of Technology; the Cotton Company named the School of the Art Institute of Chicago; Bu-Gay selected Illinois Institute of Technology to receive its scholarship; and Columbus assigned its two-year scholarship to the University of Cincinnati, and the one-year scholarship to the Cleveland Institute of Art. Students receiving the scholarships will be selected by the schools.

Plastic houseware entries submitted in the Competition by these molders were judged as best in design, quality, and imagination among the 214 entries submitted by 72 molders.

Designed to lend active, tangible support to a program for promoting correct design and proper application of plastics in consumer products, this Competition is the only one of its kind in the plastics industry.

Honorable Mention plaques were awarded, also, in the Competition's four classifications by a three-man judging panel which consisted of Tucker Madawick of Raymond Loewy Associates, industrial design consultants; Dr. Jesse H. Day, Editor, Society of Plastics Engineers JOURNAL; and Dr. Hugh G. Wales, professor of marketing, University of Illinois, and Secretary of the American Marketing Association.

In Class I, Honorable Mention was awarded to William E. Clements Design Associates, Inc., of Cincinnati, Ohio; in Class II to Plastray Corporation of Detroit, Michigan; in Class III to Quality Molding Company of Chicago, Illinois; and in Class IV to the Plas-Tex Corporation of Los Angeles, California.

SPEaking . . .

(Continued from page 41)

entirely possible that improved output might not be obtained if, for instance, the flight depth is made too shallow on the revised screw. Experience has shown that longer extruders result in improvements in output or quality. How much improvement in each depends on the screw design.

I know of no one who feels that he has the optimum screw design. The author is no exception. Here are some general suggestions that we feel have proved successful:

Use a metering type screw with constant pitch (helix angle 20° - 24°). The feed section should be about two flights at uniform depth and have a compression section of uniform taper up to the metering section. The metering section is normally 3-4 flights long. When shorter screws (16-1) are used, final flight depth is more critical and may have to be reduced somewhat over those recommended for 20-1 screws. The chart below gives our recommendation for 20-1 dry blend screws for critical applications such as transparent garden hose. In the case of opaque formulae deeper flighted screws are generally in order and a balance must be made with output and quality requirements for specific applications.

Extruder Size (in.)	2½	3½	4½	6
Feed Flight Depth (in.)	⅜	½	¾	1
Final Flight Depth (in.)	⅛	5/32	11/64	7/32

Molderscope . . .

(Continued from page 39)

internal heated areas used, which range from 56.52 sq. in. to 518.40 sq. in. of effective heated surface.

Now how, out of such a hodgepodge of press specifications found in 1 size category alone to evolve one formula for a cylinder design that will give universal or predictable results, even with an electronic brain to figure it out? It is virtually impossible! It boils down to an almost random specification requiring a tailor-made job every time—and that is just what the polyliners made to date have been. As results come in from more users of polyliner cylinders we hope to bring you further details.

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Easy to use—just mix *Stretch* with natural polyethylene in your own plant. It's clean, dust-free, prevents risk of color contamination. Made from time-tested pigments—completely dispersed in uniform size pellets of non-toxic virgin polyethylene. *Stretch* gives you dependable performance always—without special equipment. And *Stretch* saves you 5¢ to 15¢ per product pound. Get all the facts on *Stretch* today!

*Nail brush with bristles, molded complete in one piece by Britel, Inc., Paterson, N. J. for Hollywood Brushes, Inc., Hollywood, Florida.

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Reply in confidence, stating details of experience and salary required to Box No. **1456**, SPE JOURNAL, 34 East Putnam Avenue, Greenwich, Connecticut.

Plastic Sales Engineer

We are seeking a well qualified man experienced in plastics extrusion for attractive Market Development position. Kindly give your education, experience, and expected salary in complete resume. All replies will receive careful attention and will be held confidential. Write: 108 Personnel Department, Chemical Division, Koppers Company, Pittsburgh 19, Pa.

Process Engineer

Process engineer wanted. Rapidly expanding midwest fabricating company needs experienced plastic fabrication process engineer. Write giving complete resume and salary expected. Excellent opportunity for right man. Personnel dept., Holiday Plastics, Inc., 1301 Fairfax Trafficway, Kansas City, Kansas.

Polymer Chemists

With several years experience in emulsion polymerization of vinyls, particularly vinyl chloride, vinyl acetate, acrylics or related polymers. Unusual growth opportunities for the right person to become the key man in a new department of a medium sized chemical corporation. Excellent salaries and employee benefits. Please submit complete resume to: Manager, Personnel Planning, Wyandotte Chemicals Corporation, Wyandotte, Michigan.

The Maccaferri Cylinder . . .

(Continued from page 55)

"Could we have some actual results in parts produced per hour between the Maccaferri cylinder and standard cylinders?"

There has been no attempt yet to increase the production on machines where this chamber was used, because the cycle was limited by mold and machine. The temperature settings are 100°F or more lower than with the standard heater.

"What effect would an obstruction in the gate have on polyethylene?"

A gate obstruction would aggravate the normal tendency of polyethylene to "jet" into the mold, making it almost impossible to get a good finish. Also, filling will be harder.

"What is the ratio of the number of holes (⅛") to the active (primary) surface area?"

We have established no rule of thumb—the number of holes will be limited by considerations of mechanical strength and heat transfer. In the cylinders built so far, the holes have been about ¾" apart along the top of the flutes.

Definitive Specifications . . .

(Continued from page 29)

Table II
Physical Requirements

PROPERTY	REQUIREMENT
Melt Point °F Min.	480
Relative Viscosity	46 Min.
Mandrel-Bend (Mandrel-bend number = 100 − number of breaks in 100 bends)	95
Specific Gravity	1.13 - 1.15

Table III
Test Methods

REQUIREMENT	TEST METHOD[1]
Melt Point	A. S. T. M. D789-53T
Relative Viscosity	A. S. T. M. D789-53T
Specific Gravity	A. S. T. M. D792-48T
Mandrel-Bend	A. S. T. M. D789-53T
Moisture Content	A. S. T. M. D789-53T
Solution Light Transmission	PCRD R-98
Carbon Content	W. W. 54
Granulation	W. W. QC 2.3.202
Contamination	W. W. QC 2.3.202

[1]*To be changed to military designation.*

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Our output is wholly-integrated back to basic raw materials within the Allied Chemical group. Our production is efficient, continuous, completely competitive in every respect. We welcome inquiries from present and prospective makers of adipates, adipic polyesters and polyurethans.

SEND FOR TECHNICAL BULLETIN I-12

This comprehensive 8-page technical bulletin on National Adipic Acid gives physical and chemical properties; principal reactions of the carboxyl and alpha methylene groups; solubility curve, and suggested uses with copious literature references.

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Our Hi-fax plant is underway! Construction has begun in Parlin, New Jersey on the new plant which will produce Hi-fax, a versatile new ethylene polymer made by the Hercules process.

facts about hi-fax

Hi-fax is the name of a new ethylene polymer to be made by the Hercules process. Hi-fax provides a completely new plastic with an unusual combination of properties unmatched by any material previously available.

Hi-fax is truly heat resistant! Can be immersed in boiling water without distortion. Insoluble in water or organic solvents below 100°C.

Hi-fax is rigid and strong! Hi-fax has four to five times the rigidity of regular polyethylene. It has double the strength.

Hi-fax has exceptional low temperature toughness! Retains its impact strength at extremely low temperatures.

Hi-fax has superior resistance to chemicals, solvents and greases! The fluid permeability of Hi-fax is only ½ that of conventional polyethylene.

Hi-fax is richly colorful with an attractive lustrous finish!

Hi-fax is easy to fabricate! Can be molded by compression, extrusion and injection techniques and machined by conventional methods.

If you make or design toys, housewares, industrial moldings, sheet and film, pipe, bottles, or electrical insulation, Hi-fax offers a better plastic for the specific requirements you must meet. That's why we consider Hi-fax the plastic of tomorrow for tomorrow's superior products.

*Hercules trademark

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In design, production, and sales, versatile Hercocel continues its job of keeping new products on the move. Long-wearing and durable, economical and easy-to-mold, Hercocel—Hercules® cellulose acetate—is the perfect plastic for many products. The Dormeyer "Edge-Well" Sharpener, for example, is molded with Hercocel and is guaranteed by the manufacturer for one year against defects in material or workmanship. The Hercocel housing for the "Edge-Well" is molded by Plastic Precision Parts Co., 2535 West Madison St., Chicago, Ill. It is a product of the Dormeyer Corporation, Kingsbury and Huron Sts., Chicago 10, Ill.

Cellulose Products Dept.

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